AD-A042 166 KCM-WRE/YTO SEATTLE WASH F/G 8/8

ENVIRONMENTAL PLANNING FOR THE METROPOLITAN AREA CEDAR-GREEN RI--ETC(U)

DEC 74 DACW67-73-C-0022

UNCLASSIFIED NL

1 OF 6

AD A042166

Environmental Management for the Metropolitan Area
Cedar-Green River Basins, Washington

Part II
Urban Drainage

Appendix A

Regional Sub-basin Plans
Volume 1
Cedar River Basin

U. S. Army
Corps of Engineers
Seattle District

December 1974

(6)

ENVIRONMENTAL PLANNING FOR THE METROPOLITAN AREA
CEDAR-GREEN RIVER BASINS, WASHINGTON.

Part II. URBAN DRAINAGE STUDY.

APPENDIX A.
REGIONAL SUB-BASIN PLANS.
VOLUME 1. CEDAR RIVER BASIN.

RIBCO LAND AIR WATER WASTE

Technical Direction by (11) Dec 74

River Basin Coordinating Committee

(12) 530p. (15) DACW67-73-C-0022

Members	Representing
Kenneth Lowthian, Vice-Chairman	City of Seattle
Robert Gulino*, Phil Buswell	City of Seattle
Nancy Rising*, Chris Smith*	City of Bellevue, Cedar River basin
Arthur Knutson	City of Kirkland, Cedar River basin
Charles Ede*, Warren Gonnason	City of Renton, Green River basin
Pat Nevins	City of Auburn, Green River basin
Mart Kask	Puget Sound Governmental Conference
George Millman*, Robert Sloboden	Water District 108 & Cedar-Green basin water districts
Robert Meyer	Ronald Sewer District & Cedar River basin sewer districts
Ivan Day*	Lakehaven Sewer District & Green River basin sewer districts
Gustav Anderson	Rainier Vista Sewer District & Green River basin sewer districts
James Smith*, George Sherwin	Snohomish County
Jean DeSpain, Chairman	King County
Charles Gibbs**, Richard Page	Municipality of Metropolitan Seattle
Arthur Dammkoehler	Puget Sound Air Pollution Control Agency
Shirley Farley	Task Force for Citizen Participation

Ex officio members

Robert Stockman* Fred Hahn	Washington State Department of Ecology
Robert Burd	U.S. Environmental Protection Agency
Sydney Steinborn* Richard Sellevold	U.S. Army Corps of Engineers

*former member
**former member and former chairman

Study Management by

U. S. ARMY CORPS OF ENGINEERS, SEATTLE DISTRICT

Consulting Engineers

KRAMER, CHIN & MAYO — WATER RESOURCES ENGINEERS

YODER, TROTTER, ORLOB & ASSOCIATES

December 1974 410 300

ACKNOWLEDGMENTS

The Corps of Engineers expresses appreciation to the following individuals and groups for their assistance in conducting the study:

RIBCO TASK FORCE FOR CITIZEN PARTICIPATION

Shirley Farley, Chairwoman
Brad Collins, Vice-Chairman

Dale Ashley
Roy Avent
Jay Becker
Don Beuthin
Larry Hall
Edwin Hendrickson
Kay Johnson
Henry Keron
Jack Locke
Ted Mathison
Michele Meith
Bob Porterfield
Stew Sargent
Marion Sherman
Jerry Tucker
Jeanette Veasey
Forrest Walls
Bernice White
Ann Widditsch
Lon Woodbury

RIBCO URBAN DRAINAGE TECHNICAL REVIEW SUBCOMMITEE

Roy Avent
Phil Buswell
Harvey Duff
David Glaze
Robert Gulino
Dick Hibbard
George Hsieh
Michele Meith
Marvin Seabrands
George Wannamaker
Jim Webster

MUNICIPALITY OF METROPOLITAN SEATTLE

Nancy Baggott
Don Benson
Glen Farris
Pat Levine
Stephanie Liff
Theresa Murphy
Richard Page
Rod Stroope
Penny Wilson

KRAMER, CHIN AND MAYO, INC.
WATER RESOURCES ENGINEERS
YODER, TROTTER, ORLOB AND ASSOCIATES

Ark Chin	President – KCM
Ron Mayo	Executive Vice-President – KCM
Larry Rugaard	General Manager – YTO
Gerald Orlob	President – WRE
Roger Fry	Project Manager
Dick Warren	Deputy Project Manager

U.S. ARMY CORPS OF ENGINEERS

Colonel Raymond Eineigl	District Engineer
Sydney Steinborn	Chief, Engineering Division
Richard Sellevold	Chief, Planning Branch
Dwain Hogan	Chief, Urban Studies Section
Walter Farrar	Study Manager

PREFACE

This report is an appendix to the Urban Runoff and Basin Drainage Study. It contains general information on each of the regional drainage sub-basins within the Green and Cedar River Basins (State of Washington Water Resource Inventory Areas 8 & 9) and specific descriptions of all alternative drainage plans considered, including costs and environmental assessments.

The Urban Runoff and Basin Drainage Study is part of an environmental management program for the Green and Cedar River Basins in King and Snohomish Counties, Washington, and has been conducted under the auspices of the River Basin Coordinating Committee (RIBCO). Four principal studies comprise the RIBCO Environmental Management Program: Part I - Water Resources; Part II - Urban Drainage; Part III - Water Quality and Part IV - Solid Waste.

The Urban Runoff and Basin Drainage Report presents a comprehensive plan for meeting the existing and long range urban drainage needs within the ~~Green and~~ Cedar River Basin~~s~~. The study recommendations address drainage facilities, capital cost, methods of financing and institutional arrangements for effective drainage management. The recommended plans are conceptual and are intended for use by local governments as a guide in the future planning of drainage systems.

The published report is composed of the following documents:

Technical Report

Appendix A - Regional Sub-Basin Plans

Volume 1 - Cedar River Basin
Volume 2 - Green River Basin

Appendix B - Urban Storm Drainage Simulation Models

Appendix C - Storm Water Monitoring Program

This report is submitted in compliance with the terms of contract DACW67-73-C-0022 between the Seattle District, U. S. Army Corps of Engineers and KCM-WRE/YTO.

TABLE OF CONTENTS

VOLUME 1

LIST OF TABLES

LIST OF FIGURES

LIST OF MAPS

* See footnote page VI

LIST OF MAPS (continued)

*** At the lower right corner of each sheet there is a sheet number. Letter designation "a" next to the sheet number indicates a problem area map; "b", "c", "d" and "e" designations are for alternative plans. Sheets without a letter designation indicate there are no problems or alternative plan features thereon.**

PRESENT DRAINAGE SYSTEMS

NATURAL SYSTEMS

The underlying and basic drainage system within the Green and Cedar River Basins is a complex of streams, rivers, lakes, ponds, wetlands, and Puget Sound. The Urban Runoff and Basin Drainage Study has focused on 27 regional sub-basins and their stream systems, although numerous other named and unnamed streams make up this system. The two major river basins, the Green and the Cedar, have origins in the snowpack of the west slopes of the Cascades. The remaining stream courses and water bodies, while receiving precipitation in the form of snow, are primarily dependent upon rainfall as their source of water. The significant rainfall occurs from late fall to early spring. While winter flows in the streams are usually higher, perennial flows are experienced by all streams [illegible]ving a drainage area of approximately 1.5 square miles or more. The wetl[illegible]d ground water stored in permeable soils provide the main source for summ[illegible].

The lush natural vegetative cover of the region has an annual capability for returning water to the atmosphere through evapo-transpiration in excess of the amount of precipitation that actually falls.

SEMI-DEVELOPED SYSTEMS

Every stream system has some type of man-made improvement. All streams have at least a few culverts and bridges and the sub-basins in which the streams are located have some impervious surfaces such as roads, houses, businesses, etc., many of which are drained by conduits to nearby watercourses.

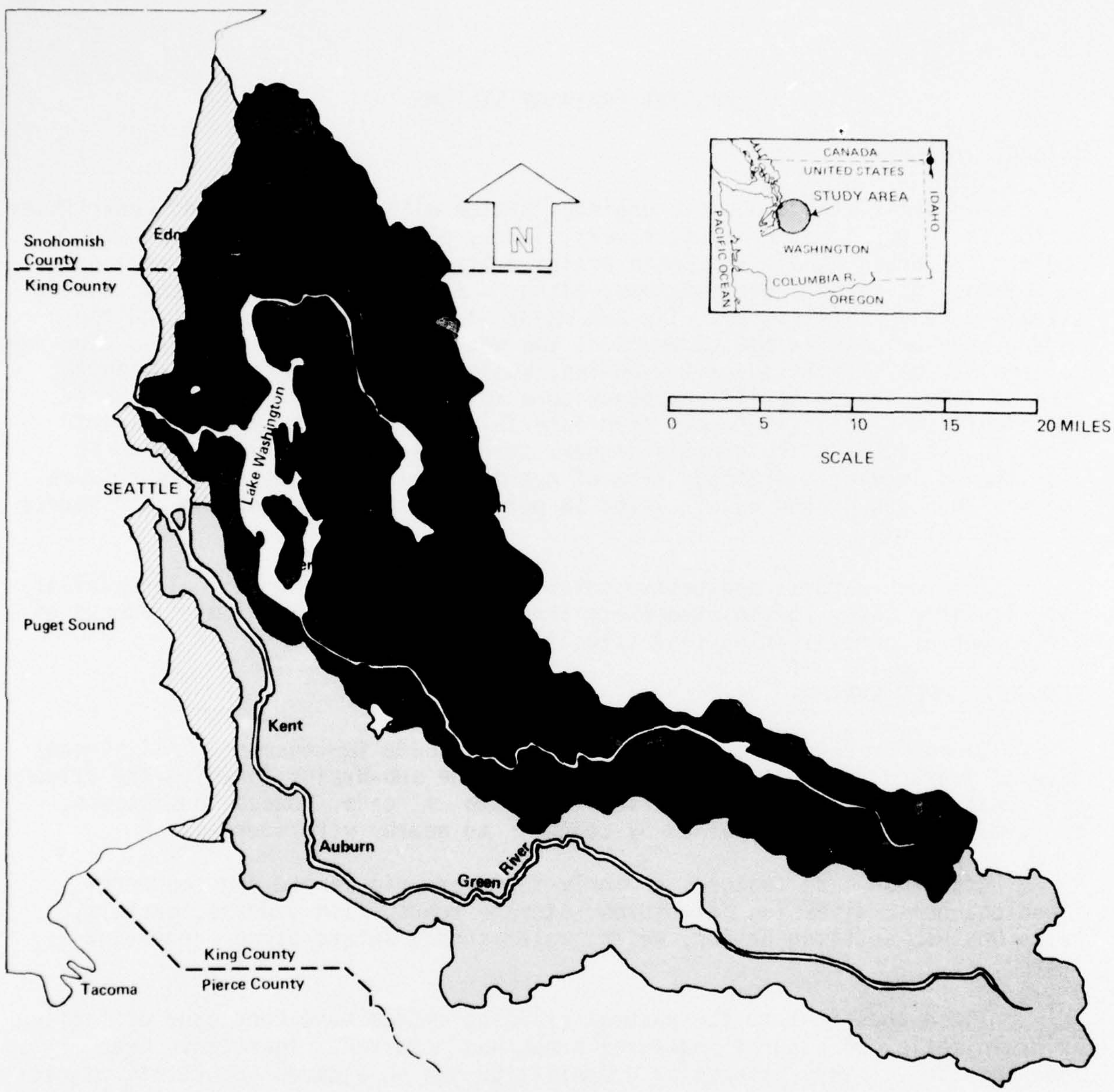
Other man-made features commonly found are rip-rapped and concrete-lined channels, diversion structures, storage ponds, fish ladders, gutters, catch basins, settling basins, weirs, water-supply intake pipes, and reservoirs.

These additions to the natural drainage system have been made primarily as urbanization of natural and rural areas has occurred. These have been made because the very process of urbanization has so altered the runoff characteristics within the watersheds that the streams need to be controlled in order to prevent major flooding, erosion and siltation.

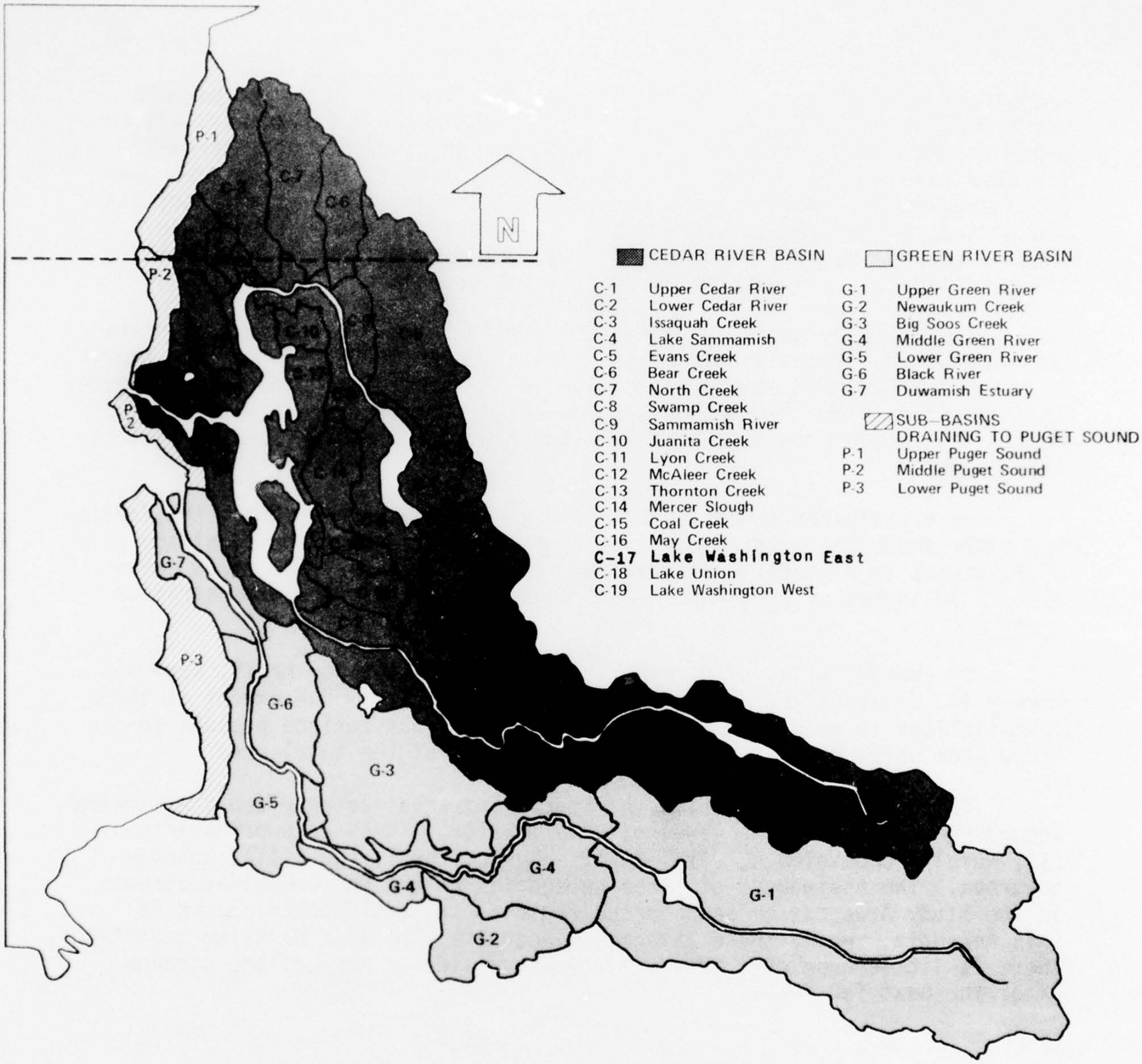
While some of the changes to the natural streams have not resulted in any significant adverse impacts, the net effect of continuing changes is a steady degradation of the natural stream system. This degradation has progressed to the point for some streams that significant fisheries resources have been lost, annual flooding is commomplace, and summer flows have become nonexistent.

FULLY DEVELOPED SYSTEMS

When a stream channel can no longer withstand the rapid runoff attendant with advanced urbanization, it is often completely encased in a pipe or



Snohomish County
King County
Edm
SEATTLE
Lake Washington
Puget Sound
Kent
Auburn
Green River
King County
Pierce County
Tacoma
N
CANADA
UNITED STATES
STUDY AREA
IDAHO
PACIFIC OCEAN
WASHINGTON
COLUMBIA R.
OREGON
0
5
10
15
20 MILES
SCALE



REGIONAL SUB-BASINS
FIGURE 2

conduit of sufficient size to accommodate any flow and is buried beneath the ground or possibly placed in a concrete channel. A stream also may be piped underground by an insensitive landowner or developer who wishes to increase the "usable" square footage of his property. The Study Area now has a significant amount of the once-natural streams in pipes and conduits. The distances that stream systems are piped varies: former streams in Seattle are now totally enclosed in pipe, but streams such as May Creek on the east side of Lake Washington have little or no pipe.

The drainage system serving the City of Seattle has a second unusual characteristic. The majority of the City has been served by combined sewers in which sanitary and storm sewage flow in the same pipe. However, the problems resulting from this method are now being corrected by a relatively costly separation program that will place almost all storm drainage systems underground.

As a basis for comparison of natural and man-made systems, the following table shows the existing lengths of natural streams, storm drainage pipes of 30 inches in diameter or larger, and combined sanitary and storm sewer systems 30 inches or larger for each regional sub-basin and demonstration area.

Of the 977 miles of streams identified in the Study Area*, approximately 147 miles or 15% are now in pipes and conduits. The extent of these installations is related to the amount of impervious surface present in the Study Area which presently is approximately 17% of the total area.

The Water Quality Management Study Report has categorized the streams according to the existing level of urbanization. These categories are: (I), Rural - Undeveloped; (II), Rural - Agricultural; and (III), Urban - Suburban. The assignment of these categories to the various named streams in the Study Area can be seen in the regional sub-basin descriptions in this Appendix. While these categories accurately reflect existing conditions, there is little hope that they will remain valid for many of the streams after the next few years.

* Excludes the Upper Green River and Upper Cedar River Sub-Basins and the main stems of the Green and Cedar Rivers.

TABLE 1

EXISTING SYSTEM INVENTORY

REGIONAL SUB-BASINS
(excluding demonstration areas)

		Natural Stream*	Pipe/Conduit**	Combined System**
C-2	Lower Cedar River	55.2 miles	-	-
C-3	Issaquah Creek	63.6	0.1 miles	-
C-4	Lake Sammamish	27.0	3.2	-
C-5	Evans Creek	75.0	0.2	-
C-6	Bear Creek	26.2	0.1	-
C-7	North Creek	21.8	0.1	-
C-8	Swamp Creek	30.2	1.2	-
C-9	Sammamish River	38.9	1.9	-
C-10	Juanita Creek	15.4	0.7	-
C-11	Lyon Creek	9.3	1.0	-
C-12	McAleer Creek	10.2	2.0	-
C-13	Thornton Creek	8.4	2.0	-
C-14	Mercer Slough	26.3	4.6	-
C-15	Coal Creek	14.9	0.5	-
C-16	May Creek	22.2	-	-
C-17	Lake Washington East	19.7	8.1	-
C-18	Lake Union	-	-	30.0 miles
C-19	Lake Washington West	8.4	3.8	21.4
G-2	Newaukum Creek	32.8	1.1	-
G-3	Big Soos Creek	65.8	-	-
G-4	Middle Green River	70.4	-	-
G-5	Lower Green River	38.1	8.8	-
G-6	Black River	33.5	4.5	-
G-7	Duwamish Estuary	10.3	11.6	12.0
P-1	Upper Puget Sound	20.3	5.2	-
P-2	Middle Puget Sound	9.7	0.4	3.0
P-3	Lower Puget Sound	19.5	2.0	6.0
	SUB-TOTALS	773.1	63.1	72.4
	DEMONSTRATION AREAS			
	Thornton Creek	11.5	4.1	-
	Kelsey Creek	15.0	1.8	-
	May Creek	- See C-16 May Creek above -		
	Mill Creek	20.1	2.8	-
	Miller Creek	9.6	3.1	-
	SUB-TOTALS	56.2	11.8	
	TOTALS	829.3 miles	74.9 miles	72.4 miles

* Excludes main stems of the Green and Cedar Rivers.
** Pipes and conduits 30 inches or larger.

PRESENT AND FUTURE URBAN DRAINAGE PROBLEMS

PRESENT PROBLEMS

During the inventory process, there also was an examination made of problems relating to drainage. There were found to be problems within existing drainage systems, such as conduits and natural systems, and also problems associated with some of the isolated lowlands or wetlands, typical of the Puget Sound geology. Problems of all types related to drainage were given consideration in the study. The same agencies which provided information on existing facilities also were asked to furnish their information on problems and damage losses resulting therefrom. In most instances, the inventory process of conditions and practices was conducted simultaneously with the examination of problems.

A complete record of all recorded and reported problems were compiled for each sub-basin. Table 2 indicates problem data sources by agency, citizen report, newspaper, or field observation for each sub-basin.

The public was asked to tell of their problems, and to give their opinions about how problems could be solved, at a series of community meetings conducted at nine locations throughout the Study Area during November, 1972. Problems were tabulated from the questionnaires completed by attending citizens. The total number of questionnaires returned and used in determining responses was 170.

Nearly all who attended the November, 1972, meetings lived in the Study Area, while two-thirds lived in an incorporated city or town. Nearly 90 percent of the citizens owned their homes. Most residents were aware of the problems involved with urban runoff during periods of heavy rainfall, while approximately 80 percent believed that these problems existed in their immediate neighborhoods. It was the consensus of 87 percent that temporary storage of stormwater runoff in their neighborhoods would be acceptable, with open fields, golf courses, roadside ditches, parking lots, and picnic areas the locations preferred, in the order listed. Very few believed that the water should be allowed to stand in the streets or their lawns and driveways, but about half were willing to permit temporary storage of stormwater elsewhere on their property.

Public opinion was overwhelmingly against the use of concrete linings in streams in order to lessen damage by stormwater runoff, while the use of a rock or boulder lining was more environmentally acceptable.

Attendees overwhelmingly favored the use of tax money to pay the cost of stormwater runoff control and believed that the cost should be shared by residents of both hillsides and low-lying areas.

Most of the attendees believed that existing control measures are insufficient to protect natural stormwater runoff channels and that zoning should be adopted for the purpose, although development of presently vacant land should not be completely halted, and streams, swampy areas, and other natural areas where development was limited should be opened for public recreational use.

TABLE 2

EXISTING PROBLEM DATA SOURCES

Sub-Basin		Municipal Files	County Files	State or Federal Report	Small Business Admin.	Damage Survey Report	Engineering Report	Citizen Report	Newspaper	Photograph	Field Observation
Upper Puget Sound	P-1	X	X				X		X		X
Middle Puget Sound	P-2	X	X		X		X		X	X	X
Lower Puget Sound	P-3	X	X		X		X	X	X	X	X
Newaukum Creek	G-2	X								X	X
Big Soos Creek	G-3	X	X			X			X	X	X
Middle Green River	G-4	X			X	X		X			X
Lower Green River	G-5	X	X	X	X	X	X	X	X	X	X
Black River	G-6	X	X	X	X	X	X	X	X	X	X
Duwamish Estuary	G-7	X		X				X	X	X	X
Lower Cedar River	C-2	X		X	X			X	X	X	X
Issaquah Creek	C-3	X		X	X	X	X	X	X	X	X
Lake Sammamish	C-4	X	X		X	X		X	X		X
Evans Creek	C-5		X	X	X		X		X		X
Bear Creek	C-6		X								X
North Creek	C-7		X				X				X
Swamp Creek	C-8	X	X		X		X	X		X	X
Sammamish River	C-9	X	X	X	X	X	X				X
Juanita Creek	C-10		X							X	X
Lyon Creek	C-11		X							X	X
Mc Aleer Creek	C-12		X					X		X	X
Thornton Creek	C-13	X						X		X	X
Mercer Slough	C-14	X	X		X		X	X	X	X	X
Coal Creek	C-15				X				X	X	X
May Creek	C-16		X				X	X		X	X
Lake Washington East	C-17	X	X		X	X	X	X			X
Lake Union	C-18	X			X	X					
Lake Washington West	C-19	X			X	X					X

They believed that building should be restricted in low-lying areas subject to seasonal flooding, but that changes to more intense use of urban or suburban lands would not be completely stopped, but rather controlled in some way. Citizens' opinions were mixed with regard to the level of government which should be responsible for control measures, but spoke most affirmatively of regional organizations, such as Metro.

Streams were considered to be important urban assets, while swamps and seasonal swampy areas were also believed to be valuable assets to the environment. Most attendees considered that building should be restricted within 100 feet of natural water runoff features, except lakes and major rivers, while streams, swamps, and seasonally swampy areas should be used for both active and passive recreation.

From the inventory process, the above described questionnaire results, and from additional problem input obtained from the public at the January, 1973, series of community meetings, maps were prepared that indicate problem location and type. These maps were used at the June, 1973, round of community meetings to show citizens the wide range of drainage problems in the Study Area.

A summary of reported problem types is listed by sub-basin in Table 3. Additional problems found during the hydraulic analysis of the existing drainage systems are included in the table.

The only water-quality problems reported by citizens were those of turbidity, and they are grouped in the table with sedimentation problems.

The most frequently reported problem was ponding or standing water, which accounted for 25% of the total problems reported. Second most frequently reported was slides, 24% of the total. The problem of slides is over representative of type and frequency due to a large amount of data received from one source, the Small Business Administration.

The ranking of documented problem types by reported events is:

Ponding	93
Slides	91
Stream Flooding	37
Ditch Flooding	35
Structural Failure	37
Sedimentation	27
Erosion	43
Home Flooding	21
Debris	10
Gutter Overflow	4
TOTAL EVENTS	398

TABLE 3
SUMMARY OF DRAINAGE PROBLEMS BY TYPE

Sub-Basin		Number of Problems Reported	Ponding	Earth Slide	Stream Flooding	Ditch Flooding	Structural Failure	Sedimentation and/or Turbidity	Erosion	Home Flooding	Debris	Gutter Overflow	Reported Damages 1972-1973
Upper Puget Sound	P-1	10		X		X	X	X	X		X		None
Middle Puget Sound	P-2	8	X	X		X	X	X	X		X		$ 19,000
Lower Puget Sound	P-3	61	X	X	X	X	X	X	X	X	X	X	101,000
Newaukum Creek	G-2	2	X		X				X				None
Big Soos Creek	G-3	5		X	X				X		X		3,000
Middle Green River	G-4	4	X	X					X		X		13,000
Lower Green River	G-5	43	X	X	X	X	X	X	X	X	X	X	109,000
Black River	G-6	22	X		X	X	X	X	X	X			82,000
Duwamish Estuary	G-7	24	X	X	X	X		X	X	X	X		245,000
Lower Cedar River	C-2	9		X	X	X		X				X	57,000
Issaquah Creek	C-3	9	X	X		X		X	X	X	X		174,000
Lake Sammamish	C-4	7		X	X	X		X	X	X	X		26,000
Evans Creek	C-5	2	X	X	X	X	X		X				4,000
Bear Creek	C-6	2	X		X	X	X		X				None
North Creek	C-7	7	X		X	X			X		X		None
Swamp Creek	C-8	11	X		X			X	X		X		2,000
Sammamish River	C-9	16	X	X	X	X			X				18,000
Juanita Creek	C-10	2	X						X				None
Lyon Creek	C-11	5	X					X	X		X		None
Mc Aleer Creek	C-12	3	X		X			X	X	X			None
Thornton Creek	C-13	42	X	X	X	X	X	X	X	X	X	X	182,000
Mercer Slough	C-14	19	X	X	X	X	X		X		X		142,000
Coal Creek	C-15	2			X				X				1,300
May Creek	C-16	2	X		X			X	X				None
Lake Washington East	C-17	53	X	X		X		X	X				184,000
Lake Union	C-18	11		X		X			X	X			87,000
Lake Washington West	C-19	17	X	X		X			X	X			57,000
TOTAL		398										TOTAL	$1,506,300

Of the reported problems, the occurrence by type of drainage system is as follows:

Open Channel (include natural streams, ditches, channels, etc.)	245
Combined Sewers	39
Storm Drains	64
Curb and Gutter Systems	6
Others	11
Overland Flow	1
TOTAL	366*

* This differs from the total problems reported because in some cases, more than one type of problem occurred at the same location.

The total number of problems is rather small by comparison to the Study Area, but are considered typical. Review of the reported problems seems to indicate that the major problems occur in open channel conveyance systems. Mostly problems occur in natural creeks or creeks that have been altered or impacted by urban runoff. Problems cited above are normally very short-lived, less than a few days.

Generalized findings are:

1) Existing storm sewers were found to be adequate except in those instances where the land use was not realistically projected at the time the storm sewers were designed.

2) Most storm sewers outfall directly to a natural channel, regardless of the channel's capacity or sensitivity to increased flows.

3) Many roadside ditches have 12-inch diameter culverts at driveways; flow capacity is not considered. Usually, the property owner or developer installs the smallest culvert as per local-agency regulations.

4) Many roadside ditches are at grades too steep to control erosion of native soil, thereby causing erosion and eventual sedimentation.

5) The number of reported problems by area are believed to be an indication of public concern and awareness, not the magnitude of problems.

The reported monetary damages obtained from local agencies are also listed in Table 3. These amounts represent damages from storm events that occurred during the years 1972 and 1973. During March, 1972, a storm with a recurrence interval of approximately 25 years occurred and caused roughly 90 percent of the reported damages for this two-year period.

The total reported damage amount of $1,506,300 probably encompasses only a small portion of the actual damages, as considerable damage was not

estimated or reported. This amount, therefore, should be considered a lower limit for any two-year period.

Within each of the demonstration areas, estimates were made of the annual damage from floods and drainage waters under existing land-use and drainage-system conditions. This information is presented in Table 4. Agricultural inundation damage was estimated to be $25 per acre per year for crop and pasture lands. All other damages were either from reported amounts, or from estimates based upon 1973 cost levels.

Because of a lack of data, it was not possible to define the extent of flood plain lands within each demonstration area. Therefore, for comparison purposes, damages per square mile of total watershed area are presented instead of the more conventional method of relating damages to only those lands within flood plains. The annual direct and indirect damages per square mile are indicated in Table 4, and totals ranged from a low of $1,200 for Kelsey Creek to $4,600 for Miller Creek. The average per square mile for all five demonstration areas was $2,700.

The demonstration areas represent a composite of the types of land-use and development conditions found throughout the Study Area. The average annual damages provide another rough estimate of total annual damages that are experienced with the existing developed and partially developed urban/suburban lands of the Urban Runoff and Basin Drainage Study Area.

Total Annual Damages: 730.5 sq. miles x $2,700/sq. mi. = $2,000,000

The figure of $2,000,000 per year is an estimate. The almost total lack of accurate data, and the enormous time and cost efforts of flood hazard appraisals make further refinement impractical at this time.

In addition to problems which have affected individual property owners, a whole series of problems plague the natural stream system.

Most notable among these are:

1. Loss of fisheries: This is due to a combination of urbanization-induced factors; siltation of spawning beds; intolerable increases in water temperature and decreases in dissolved oxygen content from vegetation removal; low flows which impede fish passage and reduce water quality (attributable to filling in of wetlands and paving over of natural ground surfaces); and construction and placement of culverts, fences, wiers, etc., which do not allow fish passage.

TABLE 4

ANNUAL DAMAGE FROM FLOODS AND DRAINAGE WATERS
(Existing Conditions)

		Thornton Creek (6.9 sq.mi.)	Kelsey Creek (9.4 sq.mi.)	May Creek (13.0 sq.mi.)	Mill Creek (13.0 sq.mi.)	Miller Creek (8.9 sq.mi.)
DIRECT DAMAGES						
Agricultural	Crop inundation			$ 2,720	$26,000	
	Damage to stored crops					
	Damage to livestock					
	Equipment and buildings					
	Sediment deposition					
	Bank erosion			350		
Urban/Suburban	Residential inundation	$ 9,250	$ 3,190	3,600	} 12,000	$ 7,300
	Commercial/industrial inundation					2,000
	Bank erosion		400		3,000	5,140
	Sediment deposition	1,000	4,350	8,800	1,500	0
	Damage prevention and clean-up by King County				1,500	20,000
Public, Semi-Public and Utilities	Roads and bridges			1,500	100	
	Railroads or airports					
	Parks		300			
	Schools or churches		1,400			
	Utilities (sewerage, electric, etc.)					
	Sub-Total	$10,250	$ 9,640	$16,970	$44,100	$34,440
INDIRECT DAMAGES						
Loss of business and/or services; Emergency services during floods; Re-routing road and railroad traffic; Impaired land use; Security and health	} 20% of direct damages	$ 2,050	$ 1,930	$ 3,400	$ 8,820	$ 6,890
Total Estimated Annual Damages ($138,490)		$12,300	$11,570	$20,370	$52,920	$41,330
Annual Damages per Square Mile (Ave. $2,700)		$ 1,800	$ 1,200	$ 1,600	$ 4,100	$ 4,600

2. Loss of wetlands: As economic pressures build within urbanizing areas, wetlands, which were previously considered unbuildable because of excessive construction costs, are developed. The high construction costs are offset by potentials of economic gain which the wetlands offer as the last undeveloped properties within the urbanizing areas. When the wetlands are drained or filled, their water retention and purification function is destroyed. The watercourse must then endure highly variable silt and pollution-laden runoff volumes unaided.

3. Degradation of water quality: Water quality problems occur in two general areas: (1) As streamside vegetation is removed, an increase in water temperature and decrease in dissolved oxygen content is experienced. (2) Pollution loads carried by streams during and after storms can be of short-term duration but of long-term consequence. Parking lot and roadway runoff (high in hydrocarbon and heavy metal pollution), runoff from fertilized lawns, and silt laden runoff from unprotected construction sites, all enter the streams during storms. Depending upon the severity or frequency, the introduction of these pollutants can have a devastating effect on the aquatic biota and dependent terrestrial fauna.

4. Loss of stream aesthetics: It is difficult to assign a dollar cost to the aesthetic value and enjoyment provided by a natural stream, and yet, pleasant moments have been provided to those people who have experienced the beauty of a rushing stream or the peaceful solitude of an upland marsh. These natural benefits disappear when streams are placed in conduit or cease to flow because a wetland area has been drained and filled over for a new housing development. Unfortunately, this type of loss occurs continually on the streams within the Study Area.

FUTURE PROBLEMS

The drainage problems that exist today begin to establish the pattern and format for problems that can be expected in the future. Unless remedial measures are taken, future drainage problems will tend to build upon and intensify drainage problems that now exist. And, in all likelihood, new problem areas will be created which do not exist at this time.

In order to help identify the magnitude and probable location of future problems, the present drainage system has been analyzed with the aid of the computer models under runoff conditions from projected future land use. This has resulted in a definition of areas where the present system will be inadequate for future land-use runoff conditions.

The general pattern which occurs begins with upstream development that does not have adequate runoff control. This leads to an overtaxing of downstream facilities which may be characterized by flooding, an accelerated erosion rate, sediment deposits on stream beds, and the formation of offshore

deltas. Many of these problems can then be transmitted further downstream in an attempt to correct them at the initial place of occurrence. Rip-rapping, dredging, diking, and channel realignment are typical of "corrective" measures which, in fact, transmit a problem further downstream.

One way to gain an easy understanding of what might happen to a stream system is to make a comparison between a sub-basin which has experienced considerable development (in excess of 15% impervious surface) and one which has experienced little development (5% impervious or less). The sub-basin which has little development usually will contain few man-made structures (culverts, retaining walls, etc.) within the stream and display few signs of erosion, siltation or past flooding. Conversely, the sub-basin which has a higher degree of development often will contain numerous control features including rip-rapped or concrete sided channels, stream sections completely enclosed in conduit, check dams, etc. and show definite signs of erosion and siltation. If the undeveloped sub-basin begins to develop without special runoff controls, the probability is quite high that it, too, will eventually require control devices and begin the gradual process of deterioration.

The following listing presents regional sub-basins and demonstration areas by the severity of drainage problems that are likely to occur by the year 2000 if corrective measures are not taken. Group One is for those basins currently experiencing severe drainage problems and in which an intensification of problems can be expected; Group Two for those that probably will experience severe damage by the year 2000; and Group Three for those expected to have less severe drainage problems by the year 2000.

GROUP ONE

Black River

Miller Creek Demonstration Area

Middle Puget Sound

Duwamish Estuary

Lower Green River*

Lake Washington East

Kelsey Creek Demonstration Area

Mercer Slough*

Thornton Creek Demonstration Area

Thornton Creek*

McAleer Creek

Lyon Creek

Juanita Creek

GROUP TWO

Lake Sammamish

North Creek

Mill Creek Demonstration Area

* See footnote page 15

Swamp Creek	Upper Puget Sound
Lake Washington West	Lower Puget Sound*

GROUP THREE

Lower Cedar River	Coal Creek
Issaquah Creek	May Creek Demonstration Area
Evans Creek	Newaukum Creek
Bear Creek	Big Soos Creek
Sammamish River	Middle Green River

*Regional sub-basins do not include the demonstration areas located therein.

The loss of additional fisheries resource and stream aesthetics can be expected if existing trends continue. Also, the educational value of the natural stream ecosystems will be lost or further removed from those who wish to make use of them. Economic costs to the community to accommodate runoff from projected future growth must be weighed against any potential economic gains the growth itself may bring. If citizens agree to spend a portion of available revenue, the use of the money (i.e. schools vs. police vs. roads vs. drainage, etc.) must be made judiciously because the correction of a problem in one area may lead to the worsening of a problem in another area.

The last major area for which future problems can be anticipated is with water quality. A gradual degradation of water quality can be expected running parallel to the pace of urbanization. Pronounced changes probably would not occur over the short-run, but can be expected to ultimately eliminate fish productivity and lower water quality in those sub-basins where significant growth is projected to occur.

ALTERNATIVE DRAINAGE PLANS

INTRODUCTION

The alternative drainage plans, described in this section, represent reasoned approaches for each of the regional sub-basins and demonstration areas. They report the existing and projected land-use and drainage situation and they reflect a consideration for what is possible, feasible and desirable in view of the general goal to obtain the greatest benefits to the community and its environment. The alternative plans are not intended to be final plans for the design of specific physical facilities, but they are based upon an accumulation and integration of facts that are necessary prerequisites for design and implementation, including community action.

Plan development processes from which the alternatives are derived are explained in more detail in the Technical Report.

LAND-USE PROJECTIONS

The alternative drainage plans have been developed to provide methods for accommodating runoff from land under use conditions projected for the year 2000. Each of the regional sub-basins and demonstration-area projections were based upon common methodology for population, economic and land-use allocation forecasting, and are consistent with forecasts used for other RIBCO studies. These land-use forecasts were provided by the Puget Sound Governmental Conference (PSGC) on the basis of census tracts through the use of an Activity Allocation Model (AAM) which distributes region-wide forecasts of population and economic activity to a number of small districts. The AAM output was not directly usable for the Urban Runoff and Basin Drainage Study because the reported districts were not based upon drainage sub-basins. Local Planning Agencies reworked the land-use projections provided by the AAM to conform with sub-basin boundaries.

The land-use projections for the year 2000 were prepared for two alternative growth concepts, designated as the Comprehensive Plan and the Corridor Plan. The PSGC defines these concepts as follows:

Comprehensive Plan

This concept assumes continuation of the past decade's growth trends and development policies, but with some accommodation for plans to reach land-use goals in an orderly manner. Major features include:

1. Acquisition of open space as demands rise and finances permit, but with acquisition concentrated in the urban area for specific purposes, rather than as dictated by natural factors that bear upon construction costs;

2. Location of new employment in new centers only when it cannot be accommodated by existing centers, and then with regard to plans for transportation (including high-speed mass transit) and residential development; and

3. Location of residential development relative to existing service centers instead of encouraging the establishment of new, automobile-dependent satellite communities that result from real estate speculation and promotion.

Corridor Plan

This concept assures that new development will be concentrated in corridors radiating outward from larger cities along major transportation lines. Open space separates the corridors. The concept calls for:

1. Conservation of land based upon suitability analysis of natural factors;

2. Location of new employment activities along transportation development routes (including a high-speed mass transit system); and

3. Development of residential units within existing residential areas with high-density around transit terminals and central business districts.

Land use was designated in the following categories:

- Single Family Residential
- Multi-Family and Other Residential
- Commercial Services
- Government/Education/ Institutions
- Industrial
- Parks and Dedicated Open Spaces
- Agriculture
- Special: Airports, Railyards, Freeways, Highways
- Unused Land
- Water

Existing and future land-use plans are shown in the Technical Report on Figures 9 through 11.

Analysis of runoff characteristics from either development concept produced little or no substantive change in the required drainage system except in a few isolated instances.

Storms that have 10-year recurrence intervals have been used to determine the type of problems that would be encountered by the existing drainage systems of each regional sub-basin under future land-use projections.

FORMULATION

The procedure for developing alternative drainage plans began with a field inspection of each regional sub-basin, and particularly the drainage systems.

Obstructions to flow in channels were located, as were flooded areas and other drainage problems. With the field information, the reported drainage problems, and citizen preferences in mind, drainage-system modifications were formulated and several alternative approaches were developed. Considering agency and citizen review comments, two alternatives were selected for further study.

Once the two alternative plans were scoped, potential modifications to the existing drainage system were listed. These modifications were then entered as input to the computer models and simulation runs were made. The results of this first simulation identified those elements of the system that were not correctly sized to accommodate the runoff expected under the year 2000 land use.

In the case of the alternative tending toward a non-structural approach, additional runoff controls or flood-plain zoning modifications were identified. In the alternative more closely related to a structural approach, it was often found that increasing the capacity of the conveyance system in the upstream portion of the sub-basin created a new flooding problem in the downstream reaches of the drainage system.

With an evaluation of the results of the first simulation, additional runoff controls, holding ponds, enlarged conveyance facilities, and other adjustments were proposed and a second computer simulation run was made. If the results of this second simulation indicated that all problems from the previous simulation were eliminated, no further computer runs were made. However, if problems did remain the process was repeated until they were solved.

Combinations of various elements from each of the three general drainage concepts were utilized in every sub-basin and demonstration area. Flood-plain zoning was appropriate at the farthest downstream reaches of several streams due to the physical features of the sub-basin. These flood-plain zones can be in the form of a flood plain available to the stream as in nature, or an artificial flood plain adjacent to the natural stream so that the area is available to the public for use at times when the artificial flood plain is not needed to accommodate peak rates of flow.

Runoff controls were considered in those sub-basins where a substantial portion of the land is projected to change from undeveloped to developed by the year 2000. For those sub-basins where little urban growth can take place due to the present high level of urban development, runoff controls were considered inappropriate.

Holding pond sites are available in almost all of the sub-basins, and the use of holding ponds proved to be beneficial in simulation throughout the Study Area. Wetlands and bogs also can be utilized in most of the sub-basins as runoff storage areas.

Bypass pipelines parallel to natural channels have application in areas

where the natural stream can no longer accommodate large flows. These pipelines, or diversions, will take only peak rates of flow, leaving low and natural flows in the stream.

Each alternative drainage plan developed by the URBD Study utilizes a combination of drainage concepts. However, one alternative was developed to rely more heavily upon constructed facilities, whereas the other placed a greater emphasis upon runoff control and the preservation of the natural drainage system.

The alternative plans were developed to provide methods for accommodating without flooding the storm runoff resulting from a rainfall with a 10-year recurrence interval.

In many sub-basins, existing flow restrictions, such as undersized and blocked culverts and channels, presently cause flooding and results in moderated peak flows. When these restrictions are removed as part of an alternative plan, the flooding is alleviated but the peak flow rates are increased due to the entry of additional waters to be conveyed by the improved drainage system. This increase peak-flow condition occurs in at least one alternative plan for almost all sub-basins.

For each alternative plan, the water quality concentrations at peak flows are presented for five constituents on the basis of runoff resulting from a 10-year storm. These concentrations were simulated by the computer models and represent conditions that would exist when a 10-year storm was preceded by five days with little or no rainfall.

EVALUATION

Each alternative drainage plan was field checked by a two-man assessment team to determine if the proposed plan was environmentally and socially sound. An evaluation matrix containing 34 separate elements, which were grouped into the following five general categories, was used by the assessment team and was filled out in the field:

1. Effectiveness - considers system's (alternative plan) ability to handle runoff.

2. Human Values - considers human uses and impacts of the systems.

3. Environmental Factors - considers system's natural environmental benefits and impacts.

4. Implementation - considers program mechanisms to accomplish the alternative.

5. Resource Requirements - considers expended or committed resources necessary to physically realize the alternative.

Relative weights from one to four were assigned to each element indicated on the evaluation matrix, because each element did not represent equal benefits or impacts.

The evaluation of each element, as it applies to the various drainage alternative plans, was done on the basis of a positive, negative, or neutral rating. Positive (+1) indicates that the alternative has a beneficial (least negative) impact on the element being rated. Negative (-1) indicates that the alternative has a non-beneficial (most negative) impact upon the element. Neutral (0) indicates that the alternative does not significantly affect the element. The sum of the 34 weighted elements when all receive a positive rating is plus 108, and when the elements all receive a negative rating,the sum is a minus 108.

The total score assigned to each alternative should be considered a guideline only and must be tailored by local decision makers and their staffs to reflect subsequent changes in data, conditions and values. Table 5 contains the ratings for each of the alternative drainage plans developed for the 27 regional sub-basins and five demonstration areas.

These evaluation ratings to be meaningful must be related to the descriptions and alternative drainage plans for each regional sub-basin. Although these ratings provide a general guide to the overall acceptability of an alternative, the real value of the evaluation process has been the opportunity it provided for continuous evaluation during the planning process itself.

Existing Conditions

An existing-conditions rating has been shown for each sub-basin in an attempt to give an overview of the relative condition of the natural drainage systems. This rating, while using the same range of values as the alternative matrix, is not based upon the numerous factors used for alternative plan evaluation and therefore should only be considered a generalized rating when compared to ratings for alternative plans. The rating is entirely subjective but was accomplished after field checking each drainage system.

High scores were assigned to streams such as Newaukum and Big Soos because of the relative absence of man-made drainage facilities or encroachments. Ratings in the neutral range (-27 to +27) indicate strong influence upon the stream system by man-made drainage facilities or development. Streams in this range are in a critical condition and require immediate attention if they are to continue as positive elements of the drainage system, while at the same time remaining environmentally stable. Thornton Creek, Lyon Creek, Mill Creek, and Kelsey Creek all fall into this range. Ratings below -27 indicate that little of the natural stream system remains or that extensive modification has been made. McAleer Creek and the Black River represent streams in this latter category.

Year 2000 Alternative Drainage Plans

The evaluation ratings applied to the alternative drainage plans indicate how the stream would be influenced by the various features of the plan. A stream which already has experienced impacts from urbanization presents a more difficult problem to solve with regard to the development of drainage plans, and is often reflected in a lower score for the alternatives considered. Conversely, a stream such as Newaukum Creek is still far enough ahead of the impacts of urbanization that solutions to control runoff cover a wide range of choices amongst which usually exists environmentally sensitive alternatives. The resultant alternative ratings are therefore generally higher than the alternatives in sub-basins where urbanization has already occurred, but lower than existing conditions due to the fact that substantial urbanization is projected for the next 25 years.

Evaluations were not made for the condition of no additional drainage improvements with continued urbanization. However, with that condition, the evaluation ratings for the year 2000 land use would be much lower than the ratings of the alternatives presented in Table 5.

The range of values in the rating for a given alternative plan reflects the severity or sensitivity of the solution needed to control runoff. As an example, where the plan suggests the channelization (channel is regraded and realined with new side slopes, and possibly a change in depth and width) of a stream, it must be assumed that at least for the short term, and possibly for the long term, much natural stream-side vegetation would be eliminated, aquatic habitats would be damaged, wildlife habitats would be reduced, water quality would be impacted, and stream aesthetics would be irreversibly lost. Additionally, cost of channelization is relatively high when compared to other less structural controls such as ground water recharge and flood-plain zoning.

Channelization may allow greater land utilization by providing a more convenient stream alignment and a greater channel capacity to prevent overtopping, but this comes at the expense of an open greenway and the loss of a natural outdoor laboratory. Channelization to meet ever-increasing runoff from new impervious surfaces accomplishes little in promoting ground water recharge and may result in unacceptable low-flow conditions.

An example of how a higher rating could be obtained would best be represented by an alternative plan utilizing runoff control. Runoff control envisions either storage (detention) or recharge (where soil types permit) of peak flows to allow the natural stream system to continue functioning without incurring erosion and overtopping. Utilizing runoff control, streamside vegetation, aquatic habitats, and wildlife habitats can continue to exist undisturbed. Water quality is enhanced through filtering or settling of sediments and general stream aesthetics remain unspoiled. Even as new impervious surfaces are developed, stream flows can remain fairly constant. Low flows are enhanced by water which has been introduced into the ground or released from detention sites. The cost of runoff control is usually less than the cost for those solutions involving extensive structural work,

TABLE 5

EVALUATION RATINGS

Regional Sub-Basins (excludes Demonstration Areas)

Regional Sub-Basin		Existing Conditions	Year 2000 Conditions Alt. I	Alt. II	Alt. III	Alt. IV
C-2	Lower Cedar River	+28 to + 54	- 9	+28	+18	
C-3	Issaquah Creek	+28 to + 54	+14	+14		
C-4	Lake Sammamish	0 to + 27	-25	+28		
C-5	Evans Creek	+83 to +108	+41	+53		
C-6	Bear Creek	+55 to + 82	+10 a.	+23 a.		
			+19 b.	+32 b.		
C-7	North Creek	0 to + 27	-40	+ 6		
C-8	Swamp Creek	0 to + 27	-34 a.	+ 3 a.		
			-34 b.	+ 3 b.		
C-9	Sammamish River	+55 to + 82	+39	+64		
C-10	Juanita Creek	0 to + 27	- 2	+50		
C-11	Lyon Creek	-27 to 0	-36	+ 8	+11	
C-12	McAleer Creek	-54 to - 28	-47 a.	+14 a.		
			-47 b.	+14 b.		
C-13	Thornton Creek	-27 to 0	-26	- 4	+24	
C-14	Mercer Slough	-27 to 0	-35	+54		
C-15	Coal Creek	+55 to + 82	+16	+63		
C-16	May Creek	+55 to + 82	-14	+32		
C-17	Lake Washington East	-54 to - 28	-15	+12		
C-18	Lake Union	-	-	-		
C-19	Lake Washington West	0 to + 27	-15	+ 4		
G-2	Newaukum Creek	+83 to +108	-26	+73		
G-3	Big Soos Creek	+83 to +108	+ 6	+74		
G-4	Middle Green River	+83 to +108	+24	+75		
G-5	Lower Green River	-82 to - 55	-49	-37		
G-6	Black River	-82 to - 55	-51	-28		
G-7	Duwamish Estuary	-54 to - 28	- 4 a.	0 a.		
			- 4 b.	-		
P-1	Upper Puget Sound	0 to + 27	-22	- 2		
P-2	Middle Puget Sound	-27 to 0	-21	+ 8		
P-3	Lower Puget Sound	0 to + 27	- 2	+ 4		
Located Within			**Demonstration Areas**			
C-13	Thornton Creek Demo	-27 to 0	-31	-35	+16	+21
C-14	Kelsey Creek Demo	-27 to 0	-32	+67		
G-5	Mill Creek Demo	0 to + 27	-47	+ 9	-30	
P-3	Miller Creek Demo	-27 to 0	-12	-14	+ 8	
---	May Creek Demo (See C-16 above as Demonstration Area encompasses entire regional sub-basin)					

a. Comprehensive Land Use Plan
b. Corridor Land Use Plan

such as channelization or conduits.

Other factors which influence the rating of an alternative are less dependent upon the type of solution being considered and more dependent upon the jurisdictional, economic, and legal framework within which the stream system exists and therefore tend to be more equal for various alternatives considered.

The five demonstration areas, Thornton Creek, Kelsey Creek, May Creek, Mill Creek and Miller Creek, each represent different natural conditions, different levels of human encroachment and obviously different problem/solution relationships. The process for evaluation was the same as that used for the other sub-basins although the detail of the alternative plans was greater and the solutions somewhat more intricate.

The preferred alternative for each of the demonstration areas registered a positive rating while only May Creek and Mill Creek had been considered as having a positive natural existing condition. This indicates that solutions to drainage problems, in these areas, can have a positive effect. The greater detail of study in the demonstration areas resulted in a somewhat more tailored solution and may have been reflected in higher scores for the preferred alternatives.

COSTS

Capital Costs

The estimated capital expenditures needed to accomplish the alternative plans for the various regional sub-basins are shown in Table 6. These costs are based upon actual construction costs in the Seattle area for June, 1973, and represent an Engineering New Record construction cost index of 1760. The costs included 50 percent for contractor profit, engineering, legal and contingencies. In addition, land costs, at 1973 prices, are included plus 50 percent for severance and acquisition. A detailed listing of unit prices is presented in Appendix B.

The total of the highest cost alternatives for each of the regional sub-basins is $102,100,000 based upon the Comprehensive land-use plan. The total drops to $98,400,000 for the Corridor land-use plan. Totals for the lowest-cost alternative for the comprehensive and corridor land-use plans were $67,500,000 and $66,800,000, respectively. Unit cost per square mile based upon 686.4 sq. miles, requiring separate drainage improvements, for highest and lowest cost plans amount to $149,000 and $97,000, respectively.

For the demonstration areas, the unit costs range from $123,000 to $46,000 per square mile for May Creek to $775,000 to $528,000 per square mile for Miller Creek. These values reflect the impact of urbanization upon storm drainage costs as May Creek is relatively undeveloped and Miller Creek is nearing complete development.

In all cases, the estimated capital costs are for trunk drainage systems only (accommodating 20-30 cfs). Depending upon the configuration and use of the land surface, the smallest element of a trunk drainage system would serve a watershed of roughly 30 to 100 acres.

The costs for building and house drains, storm water inlets, collector pipes, ditches, and laterals would vary from approximately $300 per acre for low density residential to $5,000 per acre for conventional storm sewer pipe systems in commercial areas, and would be in addition to the cost of the trunk drainage system.

Operation and Maintenance Costs

All of the drainage systems set forth in the alternative plans must be operated and maintained. The operation and maintenance for each system within the regional sub-basin and demonstration areas is estimated to cost annually one percent (1%) of the capital cost of the alternative drainage plan. Included in the cost are all personnel, equipment, supplies, and administration and general expenses necessary to operate and maintain channels and pipes, such as the removal of debris and sediment, unclogging of culverts, and vegetation and erosion control.

This one percent annual cost would be in addition to the annual costs

ESTIMATED CAPITAL COSTS OF ALTERNATIVE DRAINAGE PLANS

TABLE 6

REGIONAL SUB-BASINS a.

	Regional Sub-Basin	Drainage Area (Sq. Miles) b.	Alternative I	Alternative II	Alternative III	Alternative IV
C-2	Lower Cedar River	72	$ 800,000	$ 1,100,000	$ 1,800,000	
C-3	Issaquah Creek	58	500,000	500,000		
C-4	Lake Sammamish	35	2,200,000	1,700,000		
C-5	Evans Creek	49	1,700,000	900,000		
C-6	Bear Creek	17	2,000,000 c.	1,600,000 c.		
			1,100,000 d.	700,000 d.		
C-7	North Creek	29	9,100,000	2,900,000		
C-8	Swamp Creek	24	10,600,000 c.	5,200,000 c.		
			8,200,000 d.	5,200,000 d.		
C-9	Sammamish River	26	900,000	700,000		
C-10	Juanita Creek	7	1,900,000	1,800,000		
C-11	Lyon Creek	3.8	400,000	600,000	400,000	
C-12	McAleer Creek	8	3,200,000 c.	1,700,000 c.		
			3,200,000 d.	1,700,000 d.		
C-13	Thornton Creek	5.1	1,700,000	3,700,000	1,400,000	
C-14	Mercer Slough	7.4	5,600,000	700,000		
C-15	Coal Creek	7.2	2,100,000	700,000		
C-16	May Creek				(See Demonstration Area Below)	
C-17	Lake Washington East	32	2,700,000	1,600,000		
C-18	Lake Union	14 e.	No Alternatives Developed.			
C-19	Lake Washington West	28 f.	1,100,000	1,700,000		
G-2	Newaukum Creek	27	400,000	300,000		
G-3	Big Soos Creek	72	900,000	200,000		
G-4	Middle Green River	67	100,000	100,000		
G-5	Lower Green River	23	10,800,000	9,300,000		
G-6	Black River	27	19,100,000	17,700,000		
G-7	Duwamish Estuary	25 g.	2,300,000 c.	2,900,000 c.		
			2,500,000 d.	———		
P-1	Upper Puget Sound	22	6,500,000	4,000,000		
P-2	Middle Puget Sound	16 h.	2,400,000	1,300,000		
P-3	Lower Puget Sound	29 i.	8,700,000	8,600,000		
	TOTAL	730.5	Total of the Highest Cost Alternatives		Comprehensive	102,100,000
					Corridor	98,400,000
			Total of the Lowest Cost Alternatives		Comprehensive	67,500,000
					Corridor	66,800,000

DEMONSTRATION AREAS

Located Within						
C-13	Thornton Creek	6.9	2,900,000	4,500,000	2,500,000	3,500,000
C-14	Kelsey Creek	9.4	4,000,000	900,000		
C-16	May Creek	13	1,600,000	600,000		
C-5	Mill Creek	13	6,400,000	6,700,000	5,800,000	
P-3	Miller Creek	8.9	4,700,000	6,300,000	6,900,000	
	TOTAL	51.2				

FOOTNOTES

a. Regional sub-basin costs and areas (square miles) do not include the costs and areas of the demonstration areas located therein.
b. Excludes water surface areas of Lake Washington, Lake Sammamish, Lake Union, and Green Lake.
c. Year 2000 Comprehensive land use plan.
d. Year 2000 Corridor land use plan.
e. Entire area served by combined sanitary-storm sewer system.
f. Includes 19 square miles served by combined sanitary-storm sewer system.
g. Includes 0.2 square miles served by combined sanitary-storm sewer system.
h. Includes 5.5 square miles served by combined sanitary-storm sewer system.
i. Includes 5.4 square miles served by combined sanitary-storm sewer system.

now being expended by local agencies for operation and maintenance of their respective drainage systems as they now exist. The present and past operation and maintenance costs are not well documented, but are reported to be very small.

Alternative drainage plans utilizing ground water recharge facilities and holding ponds may have a slightly higher operation and maintenance cost than alternative plans comprised primarily of land-use restrictions, natural lakes, and closed pipe systems. However, because of the lack of site details and the preliminary nature of the alternative plans presented herein, operation and maintenance costs have been considered to be a uniform percentage of the respective alternative plan capital costs.

In addition to the operation and maintenance cost described above, there are two regional sub-basins and one demonstration area that have pumping plants in connection with the alternative drainage plans. Gravity flow alternatives were not possible in any of these three areas because of the high water level in the Green River. The estimated annual operation, maintenance (including overhaul, repair and part replacement), and power costs for these three are as follows:

	Alternative Plan I	Alternative Plan II	Alternative Plan III
Lower Green River Regional Sub-Basin (excludes Mill Creek Demo Area costs)	$ 70,000	$ 60,000	None
Black River Regional Sub-Basin (includes existing P-1 Pumping Plant)	$140,000	$140,000	None
Mill Creek Demonstration Area	$ 90,000	$ 70,000	$90,000

The above pumping-plant amounts were added to the previously described one percent costs to arrive at the total annual operation and maintenance cost shown in Table 7.

These estimated costs are for trunk drainage systems only, and do not include costs for the operation and maintenance of collector pipes and ditches, and laterals. These operation and maintenance costs do not include the cost of drainage management, short and long-range planning, runoff quantity and quality monitoring, accounting and billing, and other associated tasks required if a public utility drainage management organization was established. The formulation of, and the estimation of costs for, a comprehensive drainage utility organization are complex and beyond the scope of this study.

ESTIMATED OPERATION AND MAINTENANCE COSTS OF ALTERNATIVE DRAINAGE PLANS

TABLE 7

REGIONAL SUB-BASINS a.

	Regional Sub-Basin	Drainage Area (Sq. Miles) b.	Alternative I	Alternative II	Alternative III	Alternative IV
C-2	Lower Cedar River	72	$ 8,000	$ 11,000	$ 18,000	
C-3	Issaquah Creek	58	5,000	5,000		
C-4	Lake Sammamish	35	22,000	17,000		
C-5	Evans Creek	49	17,000	9,000		
C-6	Bear Creek	17	20,000 c.	16,000 c.		
			11,000 d.	7,000 d.		
C-7	North Creek	29	91,000	29,000		
C-8	Swamp Creek	24	106,000 c.	52,000 c.		
			82,000 d.	52,000 d.		
C-9	Sammamish River	26	9,000	7,000		
C-10	Juanita Creek	7	19,000	18,000		
C-11	Lyon Creek	3.8	4,000	6,000	4,000	
C-12	McAleer Creek	8	32,000 c.	17,000 c.		
			32,000 d.	17,000 d.		
C-13	Thornton Creek	5.1	17,000	37,000	14,000	
C-14	Mercer Slough	7.4	56,000	7,000		
C-15	Coal Creek	7.2	21,000	7,000		
C-16	May Creek				(See Demonstration Area Below)	
C-17	Lake Washington East	32	27,000	16,000		
C-18	Lake Union	14 e.	No Alternatives Developed.			
C-19	Lake Washington West	28 f.	11,000	17,000		
G-2	Newaukum Creek	27	4,000	3,000		
G-3	Big Soos Creek	72	9,000	2,000		
G-4	Middle Green River	67	1,000	1,000		
G-5	Lower Green River	23	178,000	153,000		
G-6	Black River	27	331,000	317,000		
G-7	Duwamish Estuary	25 g.	23,000	29,000		
			25,000	——		
P-1	Upper Puget Sound	22	65,000	40,000		
P-2	Middle Puget Sound	16 h.	24,000	13,000		
P-3	Lower Puget Sound	29 i.	87,000	86,000		
	TOTAL	730.5				

Total of the Highest Cost Alternatives	Comprehensive	1,231,000
	Corridor	1,194,000
Total of the Lowest Cost Alternatives	Comprehensive	875,000
	Corridor	868,000

DEMONSTRATION AREAS

Located Within						
C-13	Thornton Creek	6.9	29,000	45,000	25,000	35,000
C-14	Kelsey Creek	9.4	40,000	9,000		
C-16	May Creek	13	16,000	6,000		
C-5	Mill Creek	13	154,000	137,000	148,000	
P-3	Miller Creek	8.9	47,000	63,000	69,000	
	TOTAL	51.2				

FOOTNOTES

a. Regional sub-basin costs and areas (square miles) do not include in the costs and areas of the demonstration areas located therein.
b. Excludes water surface areas of Lake Washington, Lake Sammamish, Lake Union, and Green Lake.
c. Year 2000 Comprehensive land use plan.
d. Year 2000 Corridor land use plan.
e. Entire area served by combined sanitary-storm sewer system.
f. Includes 19 square miles served by combined sanitary-storm sewer system.
g. Includes 0.2 square miles served by combined sanitary-storm sewer system.
h. Includes 5.5 square miles served by combined sanitary-storm sewer system.
i. Includes 5.4 square miles served by combined sanitary-storm sewer system.
j. All costs in this table are in addition to the annual costs now being expended by local agencies for operation and maintenance of the drainage systems as they now exist.

QUALIFICATIONS

The alternative plans presented in this appendix represent a continuation of the efforts of King and Snohomish Counties and local agencies to develop drainage plans which respond to projected land use and future runoff characteristics on a watershed by watershed basis. The land-use allocation procedure which formed the basis for runoff projections is at best, preliminary. The first concern is that land use has never been aggregated or projected on the basis of watershed boundaries. This results in a questionable basis for comparison with future land use. Secondly, the Activity Allocation Model distributed future population and economic activity (and resultant land use) on the premise of growth trend continuation. This premise is highly questionable and subject recently to close scrutiny by many elected public officials, organizations and the general public. While this study did not attempt to reallocate land use based upon the runoff problems it forecast, the value and need for such a study is apparent.

Another area where the alternative plans need refinement is in the definition of the existing drainage systems. Many man-made improvements are a matter of public record. Unfortunately, many more are not, thus making the task of mathematically describing the system for computer analysis that much more uncertain. The record of natural stream, floodway and wetland conditions is almost unwritten.

Closely associated with this problem is the lack of stream-flow gages, water-quality monitoring stations and rainfall gages, all of which are needed to gain an accurate idea of actual and probable future runoff problems within the various watersheds.

The alternative plans do establish the order of magnitude of the runoff problem under projected land use conditions and can serve as the basis for developing more specific drainage plans in the future. They have helped to identify the sub-basins of high priority drainage needs and have established the runoff control and water-quality improvement functions of wetlands and natural storage sites.

The process that has started must be improved upon and continued if the region is to seriously pursue the preservation of its many streams and wetlands.

The results of the water quality model simulation for each of the subbasins are useful to compare between basins. Before extrapolating to other uses, however, the limitation should be reviewed as described in Appendix B, Urban Storm Drainage Simulation Models, and Appendix C, Storm Water Monitoring Program.

REGIONAL SUB-BASINS

This section contains descriptions and possible alternative drainage plans for each of the following 17 regional sub-basins. These sub-basins, plus the Upper Cedar River Sub-Basin*, provide the drainage network for the entire Cedar River Basin. They are bound following page 31.

CEDAR RIVER

C-2 Lower Cedar River

C-3 Issaquah Creek

C-4 Lake Sammamish

C-5 Evans Creek

C-6 Bear Creek

C-7 North Creek

C-8 Swamp Creek

C-9 Sammamish River

C-10 Juanita Creek

C-11 Lyon Creek

C-12 McAleer Creek

C-13 Thornton Creek

C-14 Mercer Slough

C-15 Coal Creek

C-16 May Creek (See Demonstration Area)

C-17 Lake Washington East

C-18 Lake Union

C-19 Lake Washington West

Descriptions and alternative drainage plans for the regional sub-basins within the Green River Basin and those draining directly to Puget Sound are presented in Volume 2.

* Because of extensive public ownership, this sub-basin is not considered developable.

DEMONSTRATION AREAS

In addition to the development of alternative drainage plans for each of the 27 regional sub-basins, five areas were selected by RIBCO for more detailed analysis, greater local citizen involvement, and additional use of drainage simulation models. In all, a total of 39 separate areas were proposed by local, state and federal agencies, consulting firms, and individuals for special consideration. From these 39 proposals, the following five demonstration areas were chosen:

1. Thornton Creek (North Fork) - part of Thornton Creek Sub-Basin

2. Kelsey Creek - part of Mercer Slough Sub-Basin

3. May Creek - the entire regional sub-basin

4. Mill Creek - part of the Lower Green River Sub-Basin

5. Miller Creek - part of the Lower Puget Sound Sub-Basin

For each demonstration area, more detailed data was obtained regarding the existing drainage system and the existing land use. With the additional data, it was possible to obtain more detailed analysis of urban runoff within the demonstration areas.

Special public meetings were conducted within the various demonstration areas for the purpose of examining alternative approaches to drainage design. Based upon the results of these meetings, alternative plans were developed which best satisfied the physical requirements of the area and the preferences expressed by local citizens.

Following plan development, citizens and local agencies again reviewed the alternatives. The alternatives were evaluated using the matrix. A completed matrix is presented for each of the alternative plans considered for the demonstration areas.

For each demonstration area, certain features of the alternative drainage plans are desirable for early implementation. These features, or facilities, are needed to correct present problems, and those predicted to occur during the next ten years that are urgent and severe. The present and future drainage problems were identified as previously described. Computer simulations of existing drainage systems under existing land use were made to determine peak flow rates, to verify the reported problems, and to better determine the extent and severity of the problems.

The physical facilities suggested for early action have been placed into the three categories defined as follows:

1. CATEGORY I - COMMON ALTERNATIVE ELEMENTS. Certain provisions for drainage control are common to all reasonable alternatives proposed for that demonstration area. Early action can begin for these features as it is reasonable to assume that they eventually will be necessary and are therefore compatible to any future course of action.

2. CATEGORY II - ALTERNATIVE ELEMENTS COMMON IN SCOPE. In each demonstration area, there are elements that are common to all alternatives set forth, but which differ only in the size of facility required. For example, if one alternative proposes a "three-barrel" culvert at a certain location and the other alternative would have two, then it is reasonable to assume that one or two "barrels" installed to mitigate an urgent problem would continue to be useful in the long term.

3. CATEGORY III - RESPONSE TO REPORTED DRAINAGE PROBLEMS. A problem that might be minor, relative to the overall alternative drainage plans, both in terms of cost and potential consequences, can be a major problem for an individual or group of residents. Each jurisdiction should establish a temporary procedure for responding to reports of problems and citizen complaints until a permanent maintenance and operations arm of a future management entity can be formulated and funded.

The demonstration area descriptions also contain an estimate of reported annual property damages as obtained from local agencies. These estimates probably are far from complete and tend to greatly underplay the magnitude of the real financial and property loss.

This section contains descriptions and possible alternative plans for the following three demonstration areas within the Cedar River Basin. They are bound following Regional Sub-Basin descriptions.

Thornton-1	Thornton Creek Demonstration Area
Kelsey-1	Kelsey Creek Demonstration Area
May-1	May Creek Demonstration Area

REGIONAL SUB-BASIN PLANS

REGIONAL SUB-BASIN C-2

LOWER CEDAR RIVER

GENERAL DESCRIPTION

This sub-basin encompasses all of the Cedar River from a point approximately two miles upstream from the Landsburg Diversion Dam to its discharge at the southern tip of Lake Washington in the city of Renton. The sub-basin is about 21 miles long, averages three miles in width, and rises from an elevation of 14.0 feet at Lake Washington to an elevation of 2,800 feet at the highest point, which lies in the extreme eastern corner.

There are eight lakes of significant size in this sub-basin, including Lake Youngs which serves as a domestic storage supply reservoir for the City of Seattle. Numerous small, unnamed streams discharge to the Cedar River but a considerable portion of the sub-basin runoff generated is discharged into the lakes high in the valley. The Cedar River is known for its excellent water quality. This is a major factor in its value as a fisheries resource, supporting runs of chinook, coho and sockeye salmon, as well as cutthroat and steelhead trout.

Highway 169 is the major transportation route in this sub-basin and it runs parallel to the river for ten miles. It connects Renton to the community of Maple Valley, and continues south until it crosses the sub-basin divide in the vicinity of Georgetown. A diversity of land use can be found in this sub-basin, including a portion of the city of Seattle's Cedar River watershed in the east, clusters of homes along the riverbank, residential developments along the bluff overlooking the river, and highly urbanized areas within the city limits of Renton. Future growth in this sub-basin is likely to be low-density residential except for areas within Renton and home developments near the city. An estimate of present and future land use is given below:

PERCENT OF SUB-BASIN AREA IN SPECIFIED LAND USE

Land Use	Existing (1970-72)	P.S.G.C. Land-Use Projection Comprehensive	Corridor
Single Family	10	20	20
Multiple Family		1	1
Commercial Services	1	1	1
Govt. and Educ.			
Industrial	1	1	1

Land Use	Existing (1970-72)	P.S.G.C. Land Use Projection Comprehensive	Corridor
Parks/Dedicated Open Space	5	5	5
Agriculture	15	15	15
Airports, Railyards, Freeways, Highways			
Unused Land	68	57	57
Water	1	1	1
Total	100	100	100
Total Impervious Area	5	10	10

The Cedar River flows mostly through unincorporated areas of King County. The only portions within the jurisdiction of another agency lie on the two geographical extremes. The Cedar River watershed lies to the east and is controlled by the City of Seattle which uses water generated therein for domestic supply. The City of Renton and the Municipality of Metropolitan Seattle, whose boundaries extend about four miles upstream from Lake Washington, are at the western extremity of the sub-basin.

NATURE OF EXISTING DRAINAGE SYSTEM

The lower Cedar River Sub-Basin is largely in a natural condition, and, because of easy access to the river channel, it is used heavily for recreation, chiefly fishing, swimming and canoeing. The Cedar River has a gradient of 21 ft. per mile for most of its length and generally can be classified in the floodway zone. Most of the creeks are undisturbed, particularly in the remote eastern end, and residential development is occurring at only three of the eight significant lakes.

Towards the west end of the sub-basin, the Cedar River passes through the confines of the City of Renton where commercial and industrial development encroaches upon the banks. About two miles of the Cedar river flows within the city limits and occupies a constructed channel, straight in alignment, with reinforced levees. Little recreational value is realized in this section.

DRAINAGE PROBLEMS

Because the eastern half of this sub-basin is largely undeveloped, few problems due to runoff occur, other than natural erosion of creek channels caused by heavy rains.

The majority of the problems occur west of Maple Valley and increase in both frequency and magnitude as the Cedar River approaches Lake Washington. Encroachment along the flood plain has resulted in periodic flooding. Urbanization, however minor at the present time, is beginning to cause heavy runoff and localized erosion in the small creeks tributary to the Cedar River. This problem is particularly evident in the natural watercourse passing through the residential development of Fairwood that lies on the hillside south of Cedar River about three miles from Lake Washington. The storm sewers constructed to drain this development discharge to the creek and cause serious erosion. Generally, silt is carried by small rivulets off hillsides denuded by recent development and slides have been observed along the valley walls.

Within the City of Renton, the problems of drainage are somewhat different. The river does not cause general flooding, but there have been instances of undesirable ponding along major arterials and flooding in a number of areas due to the lack of storm drains.

Problems in this sub-basin have been recurring for a number of years and King County has been made aware of them by both public comment and private studies. With continued growth in the area, it is only reasonable to expect flooding, erosion and siltation to increase in severity.

As described in the table of existing and projected land uses, a relatively small increase in impervious area is expected for the Lower Cedar River Sub-Basin. Development is expected to increase the impervious land area from existing 5% to approximately 10% in the year 2000.

The results of hydrologic analyses indicate no significant difference between the Comprehensive and Corridor plans, therefore, the drainage alternatives presented herein are applicable to both plans.

As this sub-basin was not a demonstration area, no computer modeling was done for existing flows along the stream and it was therefore necessary to formulate plans based upon projected problems with existing facilities being used, under future land use conditions.

BASIC ISSUES AND STATUS OF DRAINAGE PLANNING

In March, 1965, the Corps of Engineers published a report of a study of flooding in the Cedar River Basin. The study area extended from the mouth of the Cedar upstream approximately nine miles, or about halfway between Renton and Maple Valley. Some additional planning to a point above Maple Valley has been accomplished, but not formally reported. The report identified problems in the area and designated flood-plain boundaries. It also traced the history of flooding back to 1945 when the first discharge records were made, but it presented no solutions or recommendations to alleviate problems. The Corps also is involved in an ongoing flood reduction program and will incorporate the alternatives developed by the RIBCO Water Resource Management Study to develop long range solutions to flooding along the Cedar River.

Other planning efforts affecting this sub-basin include the King County Comprehensive Plan conducted in 1964 which presents general planning goals for the County, a Comprehensive Plan for Flood Control developed in 1964 which was intended to serve as a guide for future expenditures of funds for flood control, and an Urban Trails Plan completed in 1971 that identified the need for an interconnecting trail system in the Cedar River Valley.

Staff members from King County Public Works Department, Hydraulics Division, have reviewed the initial alternative plans for drainage developed by this RIBCO Study for the Lower Cedar River Sub-Basin.

ALTERNATIVE PLANS FOR PROPOSED DRAINAGE CONTROL

The existing drainage system of the Lower Cedar River Sub-Basin, as described by local agencies, was evaluated by computer simulation that applied the region's ten-year storm to year 2000 land use. Drainage problems thus identified were analyzed and possible solutions were provided in development of alternative plans for drainage control as described below.

ALTERNATIVE PLAN I

General Concept

This alternative calls for replacement of undersized storm trunk lines and surcharging culverts as well as enlarging open channels to meet future needs. Although not specifically identified through public meetings, field inspections and numerical calculations identified areas where erosion problems are occurring and will become more severe in the future. To prevent such erosion, bank protection is included as an element of the channelization solution. Included in this bank protection work are drop structures to slow velocities, thereby preventing erosion.

Major Features

The biggest single element of this plan is the storm trunk lines proposed within the city limits of Renton. These lines will parallel existing storm sewers that are inadequate to accommodate anticipated storm flows. The remaining element of this alternative includes protection of the natural channel above the Maplewood Golf Course, placement of a storm sewer parallel to the existing culvert under Highway 167 to the river, and protection of the creek that drains storm runoff from the Fairwood development situated on the plateau above the Cedar River to the south. Also included are replacement of miscellaneous culverts, enlargement of the channel flowing by the Aqua Barn Recreation Facility and protection of the banks of a number of streams in the lower portion of the basin through the use of drop structures and rip-rap.

Cost

The cost of Alternative Plan I is estimated to be $800,000.

ALTERNATIVE PLAN II

General Concept

Because of the topography and land use, the concept of detention storage is not applicable throughout the sub-basin. However, storage and controlled release may be appropriate for the problem of flooding in the vicinity of the Aqua Barn and in reducing peak flow rate in a number of the streams in adjacent areas. Such facilities would reduce downstream flows as well as damage incurred by uncontrolled ponding.

This alternative assumes that future development will follow guidelines proposed by King County so that runoff will not be permitted to increase by more than 25% above present levels. Wherever possible, flows were reduced to the point where erosion and damage along natural streams would be minimized, but to assure adequate protection of the creek banks, some rip-rap and drop structures were considered necessary. In addition, culvert replacement was included to prevent flooding and storm trunk lines were considered in the highly urbanized areas of Renton.

Major Features

The elements of this plan are similar to those described for Alternative Plan I except for the storage ponds mentioned above. In all, six storage ponds were located at various sites within the sub-basin.

Cost

The cost of Alternative Plan II is estimated to be $1,100,000.

ALTERNATIVE PLAN III

General Concept

To avoid heavy flows in the downstream portions of a number of the creeks in this sub-basin, it would be possible to divert peak runoff through trunk lines directly to the Cedar River. In the more highly urbanized areas, diversion would not be applicable. This alternative, then, considers diversion of peak flows from creeks wherever possible, and bank protection and parallel trunk sewers where diversion is not practical. In the Fairwood area, where diversion of storm flow from the creeks is not feasible, storage facilities are provided identical to those described in Alternative Plan II.

Major Features

This concept involves diversion lines above the Maplewood Golf Course and the stream passing by the Aqua Barn. Similar facilities are proposed to protect the creek east of the golf course but further consideration should be given this line after development trends become more firmly established. As described above and identified in the following tabulations three storage basins are proposed in this alternative.

Cost

The cost for Alternative Plan III is estimated to be $1,800,000.

PEAK FLOW COMPARISONS

The following table indicates 10-year peak flows under existing facilities and land use and under alternative drainage management solutions for the year 2000.

COMPARISON OF 10-YEAR PEAK FLOWS
(Cubic Feet per Second)

Location	Existing Facilities	Alternative Plan I	Alternative Plan II	Alternative Plan III
Maplewood	1200	150	90	90
Aqua Barn	220	230	130	130
Maplewood Golf Course	85	380	150	90

ENVIRONMENTAL ASSESSMENT OF ALTERNATIVE PLANS

Field inspections were made to judge the applicability of the suggested alternative plans for this sub-basin. This procedure was followed throughout the RIBCO Study in the development of alternative plans for the various regional sub-basins. Used for the inspections was the alternative evaluation proeedure which identified 34 unique criteria grouped in general categories as follows: 1) Effectiveness, 2) Human Values, 3) Environmental Factors, 4) Implementation and 5) Resource Requirements.

Various structural solutions were checked against the appropriate criteria and various non-structural solutions were reviewed for their relationship to existing and probable future developments. The criteria rating total for Alternative Plan I, which employs streambank protection and parallel conduit, was a minus 9 on a scale ranging from positive 108 to negative 108. The total evaluation rating for Alternative Plan II, which employs streambank protection, storage, parallel conduit and runoff control was a positive 28. The total evaluation rating for Alternative Plan III, which employs diversion, storage, parallel conduit, and streambank protection, was a plus 18.

All three alternatives were judged to be effective for controlling drainage, with a slight edge possibly going to Alternative Plan III because it was judged to be most reliable owing to the use of a diversion pipeline. Human values were only marginally promoted by any of the three alternatives, with Alternative Plans II and III receiving a slight edge in this category. Only Alternative Plans II and III scored positive rating for environmental factors, with Alternative Plan II being clearly superior to the other two plans. It is judged to be least harmful to wildlife and vegetation while at the same time promoting water quality and assuring low flow conditions. Alternative Plans II and III both promote the fisheries potential of the Cedar River. Negative ratings were received by all three alternative plans for probability of implementation. While only one jurisdiction is involved, no funding is available and land acquisition is necessary in all cases. All three alternatives also received a negative rating for resource requirements, although Alternative Plan II involving runoff control and storage, had a slight edge in this category. Each alternative does require construction of control facilities and single-purpose commitment of land.

One critical element in Alternative Plan II is the proposal to use runoff control and storage. This treatment combination, if it is to be part of the chosen alternative, should be implemented as an early organized effort. Any additional portion of the sub-basin that develops without these combined controls will require a more structural treatment than Alternative Plan II can accommodate. This issue should be brought to the attention of all citizens and their local agencies.

CONCLUSIONS

Alternative Plan II is judged to be slightly superior to either Alternative Plan I or Alternative Plan III. It does involve less use of man-made facilities within the sub-basin and does sustain water quality and protect low flow conditions. As pointed out above, Alternative Plan II involves runoff control, which must be implemented as an immediate action.

King County is in a position to formulate a master drainage plan for the Lower Cedar River Sub-Basin which would incorporate provisions of Alternative Plan II or any other alternative that receives adequate public and agency review. King County would be responsible for implementation and enforcement of any features of the chosen alternative.

King County should have responsibility for control of drainage and flood damage in the lower Cedar River Sub-Basin.

RUNOFF QUALITY SUMMARY
LOWER CEDAR RIVER

BASED UPON A 10-YEAR STORM PRECEDED BY 15 DAYS WITH LITTLE OR NO RAINFALL#

LOCATION	ALTERNATIVE PLAN	PEAK FLOW (cfs)	CONCENTRATION AT PEAK FLOW*				
			BOD	TOTAL COLIFORM	NH_3	$NO_2 + NO_3$	PO_4
Stream draining Fairwood south of Maplewood	I	150	1	5.2×10^3	.03	.6	.1
	II & III	90	1	6.2×10^3	.04	.7	.1
Stream draining Fairwood adjacent to Aqua Barn	I	230	1	5.7×10^3	.03	.7	.1
	II & III	130	1	6.7×10^3	.04	.8	.1
Stream draining through Maple-wood Golf Course	I	380	6	1.3×10^5	.1	.5	.2
	II	150	10	2.0×10^5	.2	.7	.3
	III	90	10	2.0×10^5	.2	.7	.3

Less than a total of 0.5 inches of rainfall in any one day.
* Concentrations in mg/liter except total coliform which is in MPN/100 ml.

EVALUATION MATRIX

LOWER CEDAR RIVER

ALTER-NATIVES	SUB TOTAL	EFFECTIVENESS								SUB TOTAL	HUMAN VALUES							SUB TOTAL	ENVIRONMENTAL FACTORS									SUB TOTAL	IMPLEMENTATION						SUB TOTAL	RESOURCE REQUIREMENTS				RATING TOTAL
		Use of existing facilities	System reliability	System maintainability	System flexibility	Flood damage reduction	Consequences of overcharge	Erosion and sedimentation control	Cost/benefits ranking		Urban quality (aesthetics)	Effect on land use	Displacement of people	Educational value	Community cohesion	Multiple use potential	Public health and safety		High flow conditions	Alteration of natural system	Effects on groundwater	Low flow conditions	Water quality	Construction disruption	Effects on wildlife	Effects on aquatic life	Effects on vegetation		Legislative requirements	Jurisdictional	Land acquisition	Public acceptance	Financing	Effects of no action		Energy	Materials	Land	Capital	
CRITERIA WEIGHT		1	4	3	2	4	4	4	2		4	2	2	1	3	3	4		4	4	4	4	4	2	4	4	4		4	4	2	4	4	3		3	3	2	2	
I	+9									0								-10										-2							-6					-9
II	+11									+4								-20										-2							-5					+28
III	+14									+4								+10										-2							-8					+18

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative I Sub-Basin Lower Cedar River

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
6	Pipe	24"	1,700'			Parallel Pipe	24"	$71,000
8	Pipe	18"	400'			Parallel Pipe	30"	$22,000
60	Pipe	18"	400'			Parallel Pipe	30"	$22,000
61	Pipe	18"	700'			Parallel Pipe	30"	$38,000
2	Pipe	24"	3,000'			Parallel Pipe	36"	$198,000
4	Pipe	24"	2,500'			Parallel Pipe	12"	$50,000
14	Pipe	36"	1,000'			Parallel Pipe	60"	$120,000
70	Misc. Culvert	Varies	800'			Replacement Culvert	Varies	$10,000
72	Culverts	Two-36"	70'			Parallel Culvert	60"	$18,000
78	Culverts	Three-36"	50'			Parallel Culvert	48"	$12,000
76	Culvert	12"	40'			Parallel Culvert	36"	$8,000
74	Culvert	12"	40'			Parallel Culvert	30"	$7,000
75	Culvert	12"	40'			Parallel Culvert	27"	$6,000
16	Channel	12'	12,000'	1:1	5'	Channel	Streambank protection and drop structures	$90,000
71	Channel	10'	5,000'	1:1	5'	Channel	Streambank protection and drop structures	$26,000
19	Channel	6'	10,000'	1.5:1	4'	Channel	Streambank protection, drop structures and channel cleaning	$66,000
79	Channel	6'	4,000'	1:1	3'	Channel	Streambank protection and drop structures	$33,000

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative I   Sub Basin Lower Cedar River

	EXISTING FACILITIES					PROPOSED FACILITIES		
ELEMENT NUMBER	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
80	Channel	1'	200'	1:1	1'	Channel	4' width 2' depth 2:1 side slopes	$1,000
22	Channel	4'	6,000'	1:1	4'	Channel	Streambank protection and drop structures	$30,000
83	Channel	4'	3,000'	1:1	4'	Channel	Streambank protection and drop structures	$15,000

The Estimated Capital Cost for each element includes Contractor profit, engineering, legal and contingencies. In addition, land purchase and severance costs are included where land is required. All costs are based upon June 1973 prices.

Total Estimated Capital Cost: $843,000

Round To: $800,000

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative II Sub-Basin Lower Cedar River

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
6	Pipe	24"	1,700'			Parallel Pipe	24"	$71,000
8	Pipe	18"	400'			Parallel Pipe	30"	$22,000
60	Pipe	18"	400'			Parallel Pipe	30"	$22,000
61	Pipe	18"	700'			Parallel Pipe	30"	$38,000
2	Pipe	24"	3,000'			Parallel Pipe	36"	$198,000
4	Pipe	24"	2,500'			Parallel Pipe	12"	$50,000
14	Pipe	36"	1,000'			Parallel Pipe	36"	$66,000
70	Misc. Culvert	Varies	800'			Replacement Culvert	Varies	$8,000
72	Culverts	Two-36"	70'			Parallel Culvert	42"	$12,000
76	Culvert	12"	40'			Parallel Culvert	27"	$7,000
74	Culvert	12"	40'			Parallel Culvert	24"	$6,000
75	Culvert	12"	40'			Parallel Culvert	21"	$5,000
71	Channel	10'	5,000'	1:1	5'	Channel	Streambank protection and drop structures	$16,000
19	Channel	6'	10,000	1.5:1	4'	Channel	Streambank protection and drop structures	$63,000
80	Channel	1'	200'	1:1	1'	Channel	4' width 2' depth 1:1 side slopes	$1,000
22	Channel	4'	6,000'	1:1	4'	Channel	Streambank protection and drop structures	$12,000

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative II Sub Basin Lower Cedar River

ELEMENT NUMBER	EXISTING FACILITIES: TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	PROPOSED FACILITIES: TYPE		ESTIMATED CAPITAL COST
83	Channel	4'	3,000'	1:1	4'	Channel	Streambank protection and drop structures	$6,000
202	None	(Upstream of Element 16)				Holding Pond	1.0 AF	$54,000
90	None	(On Element 19 in lowlands)				Holding Pond	3.6 AF	$79,000
91	None	(Upstream of Element 71: West Fork)				Holding Pond	12.9 AF	$75,000
92	None	(Upstream of Element 71: East Fork)				Holding Pond	6.3 AF	$92,000
98	None	(Upstream of Element 79)				Holding Pond	3.6 AF	$67,000
201	None	(On Element 16 in highlands)				Holding Pond	1.9 AF	$83,000

The Estimated Capital Cost for each element includes Contractor profit, engineering, legal and contingencies. In addition, land purchase and severance costs are included where land is required. All costs are based upon June 1973 prices.

Total Estimated Capital Cost: $1,053.00

Round To: $1,100,000

Alternative III   Sub Basin Lower Cedar River

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
6	Pipe	24"	1,700'			Parallel Pipe	24"	$71,000
8	Pipe	18"	400'			Parallel Pipe	30"	$22,000
60	Pipe	18"	400'			Parallel Pipe	30"	$22,000
61	Pipe	18"	700'			Parallel Pipe	30"	$38,000
2	Pipe	24"	3,000'			Parallel Pipe	36"	$198,000
4	Pipe	24"	2,500'			Parallel Pipe	12"	$50,000
93	None					Diversion Pipe	48" 2500'	$232,000
94	None			Diversion line "A" parallel to Element 71 on the west		Diversion Pipe	30" 1500'	$81,000
95	None					Diversion Pipe	42" 1100'	$87,000
96	None			Diversion line "B" parallel to Element 71 on the east		Diversion Pipe	60" 3300'	$396,000
97	None					Diversion Pipe	36" 500'	$33,000
72	Culverts	Two-36"	70'			Parallel Culvert	42"	$12,000
87	None			Diversion line "C" continuation of Element 19 to the Cedar River		Diversion Pipe	42" 1000'	$79,000
99	None					Diversion Pipe	36" 1200'	$79,000
89	None			Diversion line "D" parallel to Element 79 on the west		Diversion Pipe	21" 700'	$25,000
88	None					Diversion Pipe	30" 600'	$32,000
76	Culverts	12"	40'			Parallel Culvert	27"	$7,000

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

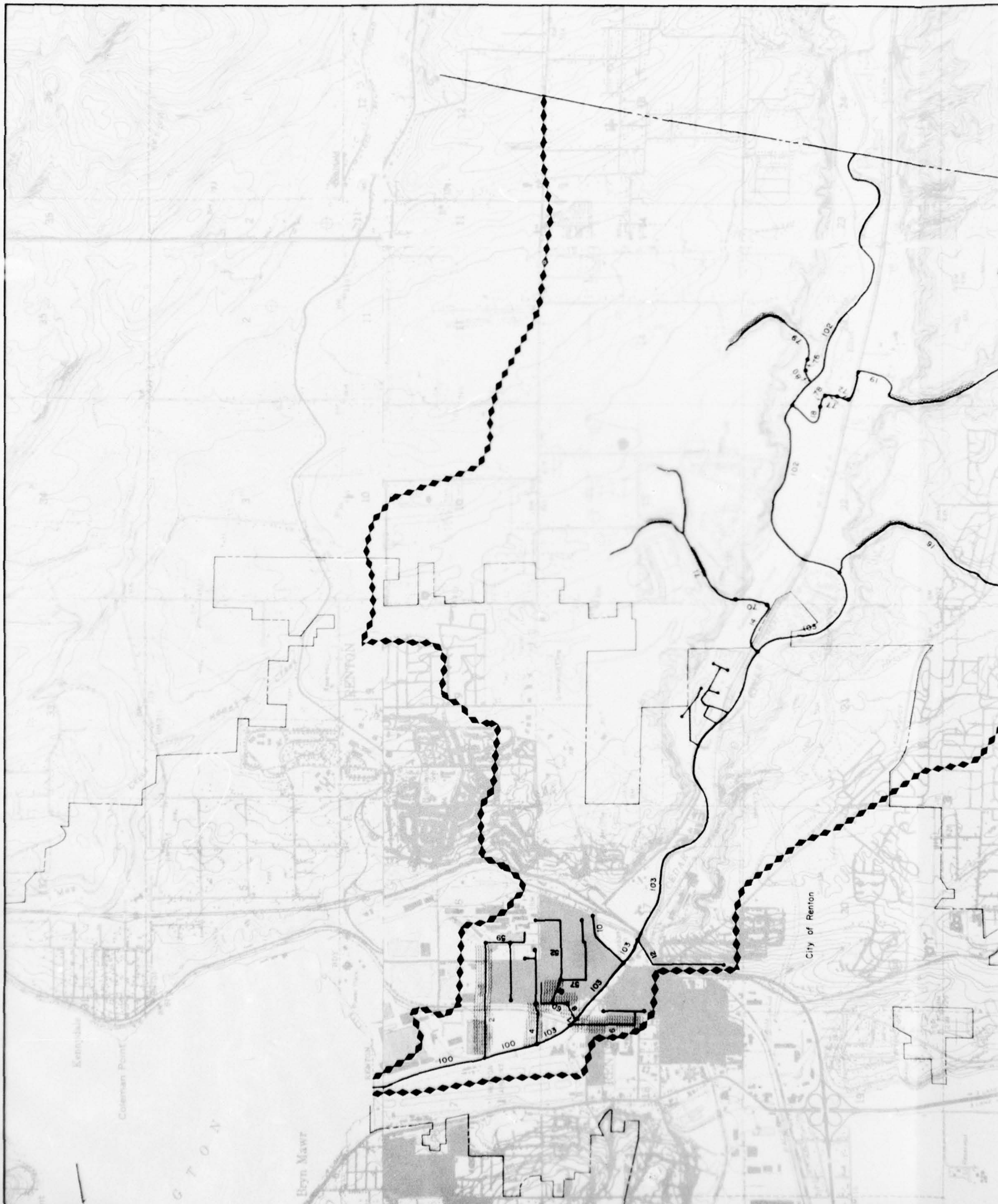
Alternative III   Sub-Basin Lower Cedar River

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
74	Culverts	12"	40'			Parallel Culvert	24"	$6,000
75	Culverts	12"	40'			Parallel Culvert	21"	$5,000
19	Channel	6'	10,000'	1:5:1	4'	Channel	Streambank protection and drop structures	$63,000
22	Channel	4'	6,000'	1:1	4'	Channel	Streambank protection and drop structures	$12,000
83	Channel	4'	3,000'	1:1	4'	Channel	Streambank protection and drop structures	$6,000
201	None	(On Element 15 in highlands)				Holding Pond	1.9 AF	$83,000
202	None	(Upstream of Element 16)				Holding Pond	1.0 AF	$54,000
90	None	(On Element 19 in lowlands)				Holding Pond	3.6 AF	$79,000

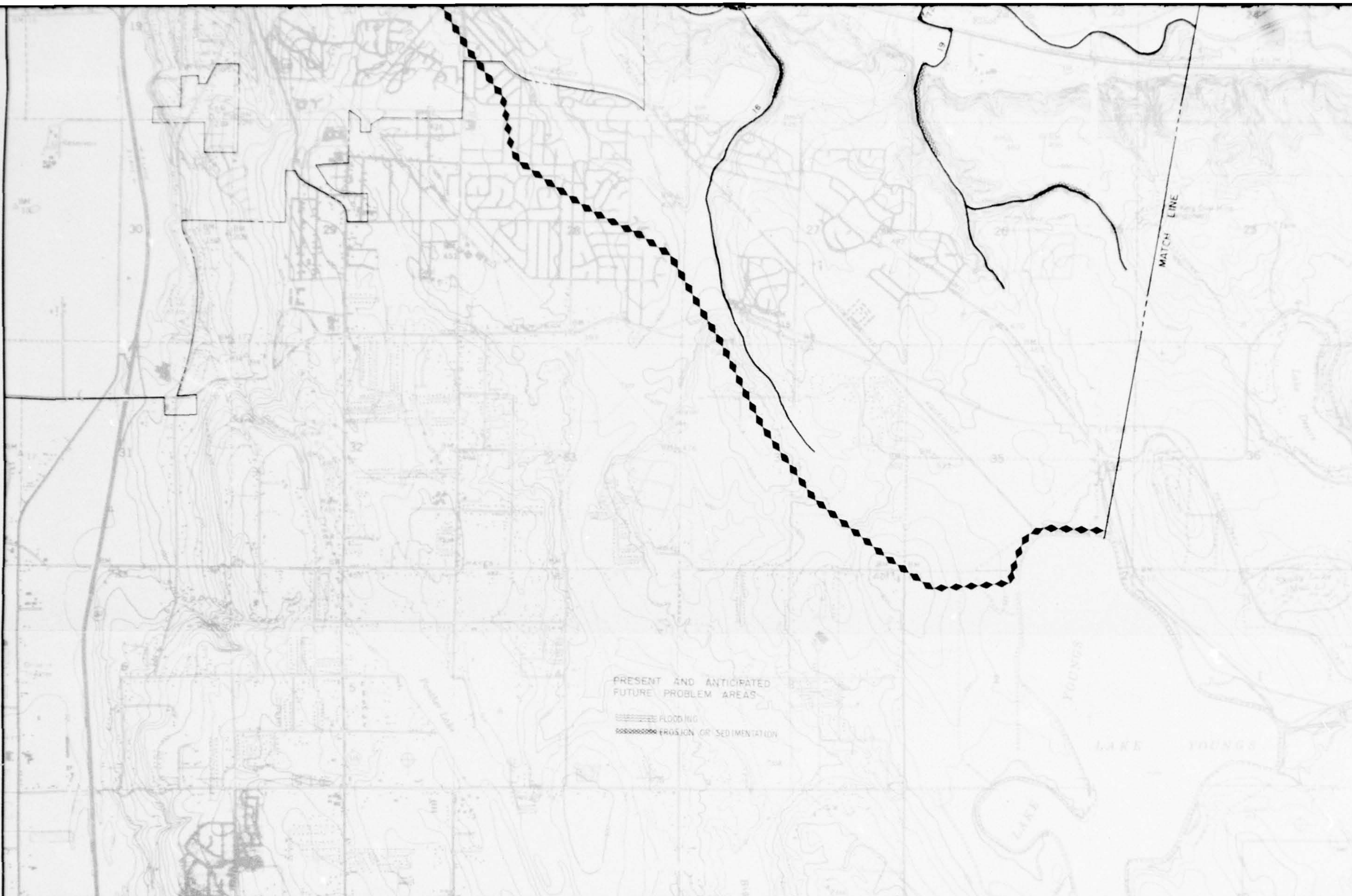
The Estimated Capital Cost for each element includes Contractor profit, engineering, legal and contingencies. In addition, land purchase and severance costs are included where land is required. All costs are based upon June 1973 prices.

Total Estimated Capital Cost: $1,772,000

Round To: $1,800,000



City of Renton
RENTON
Coleman Point
Kennydale
Bryn Mawr



LEGEND

SUB-BASIN BOUNDARY
EXISTING CHANNEL
EXISTING CONDUIT
MANHOLE, INLET, OR JUNCTION
CHANNEL OR CONDUIT DESIG. 5
CITY LIMITS
COUNTY (METRO) BOUNDARY
LEVEE

CULVERT
HOLDING POND OR LAKE

N

1/2 1/4 0 1
MILES
1000 500 0 4000
FEET

NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

LOWER CEDAR RIVER

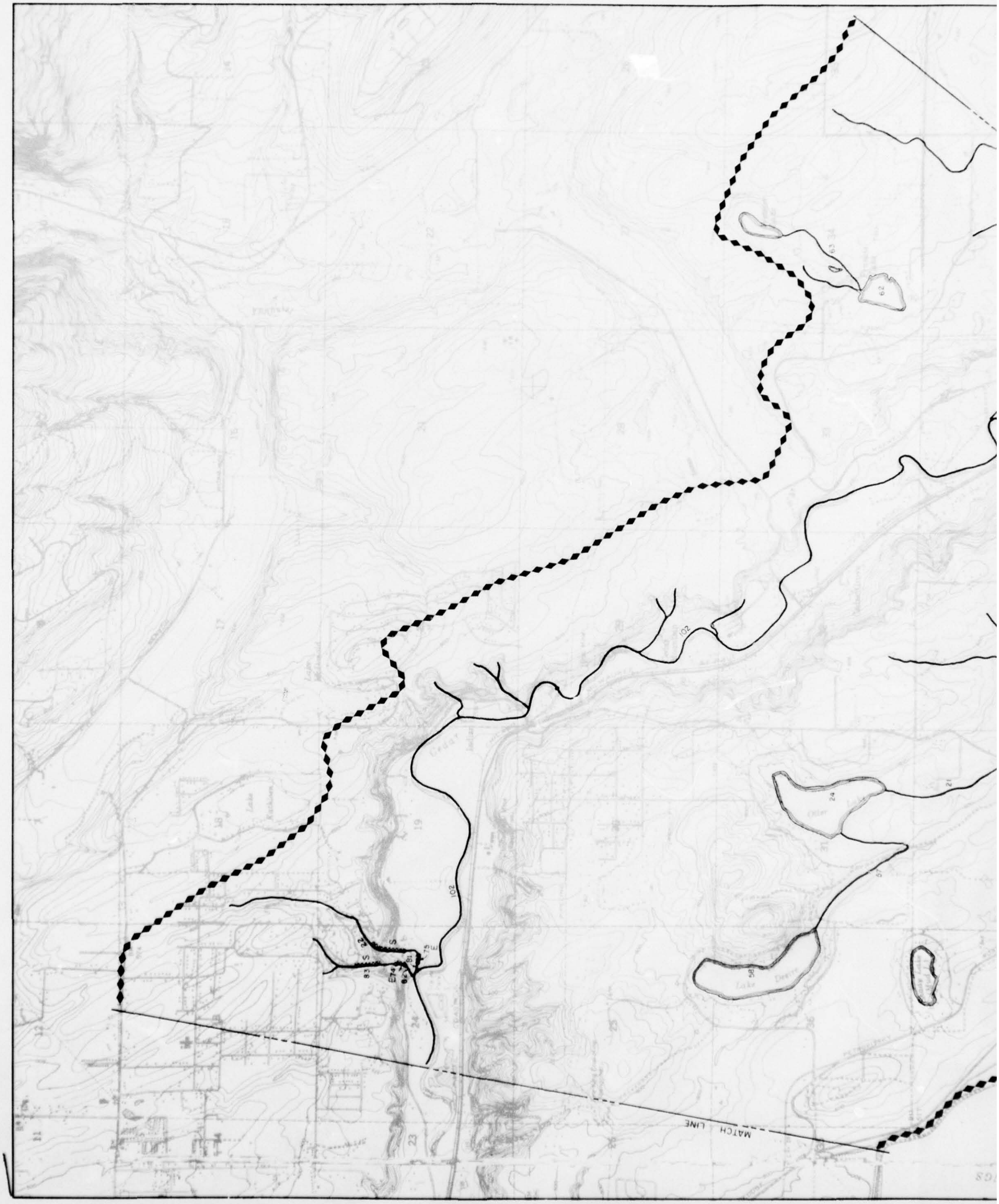
PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

KRAMER, CHIN AND MAYO, INC.
WATER RESOURCES ENGINEERS, INC.
YODER, TROTTER, ORLOB & ASSOCIATES

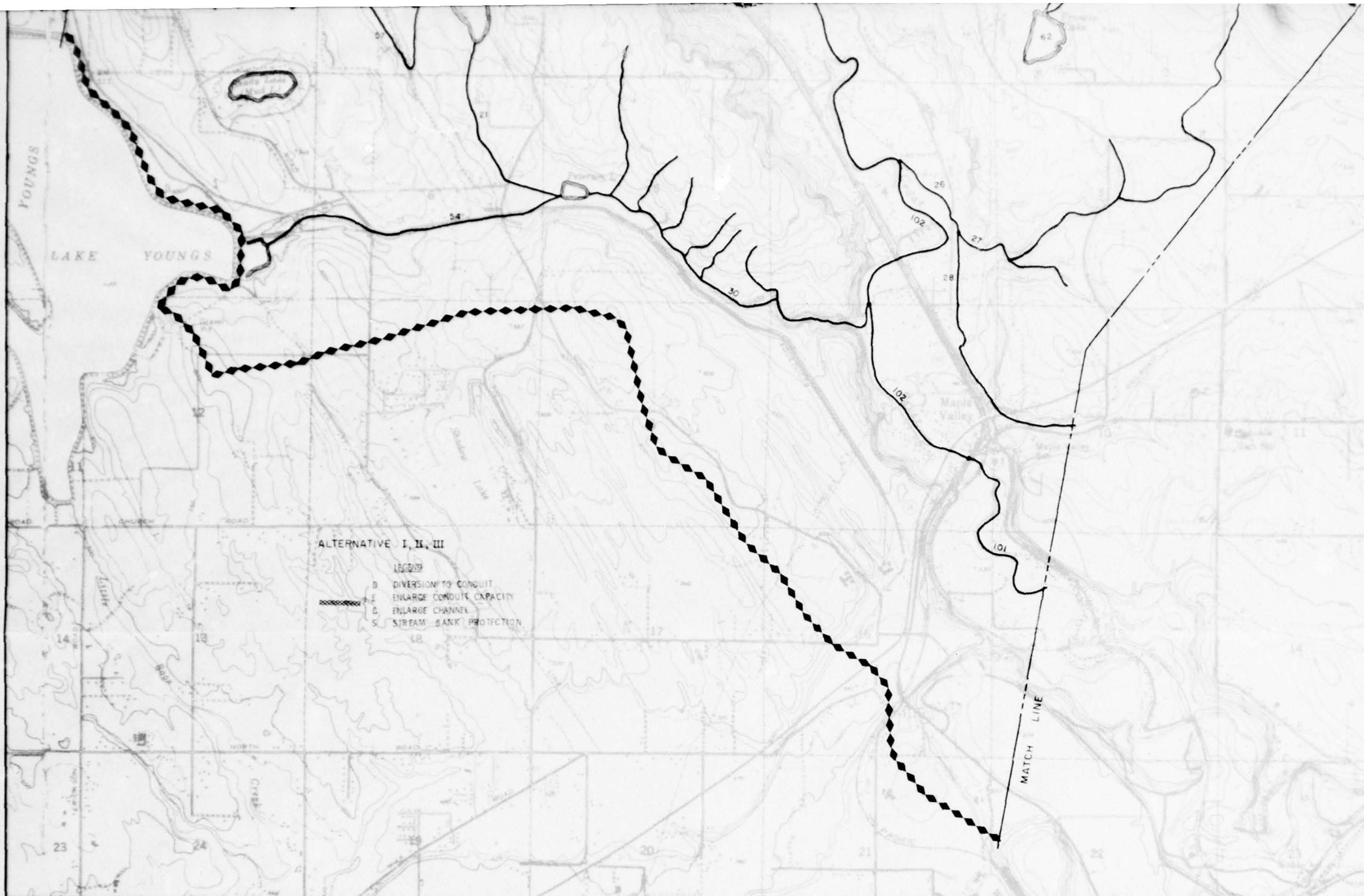
U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO. E-26-1-161 SHEET 1[illegible] OF 4

2



102
102
Lake Desire
MATCH LINE



LEGEND

SUB-BASIN BOUNDARY
EXISTING CHANNEL
EXISTING CONDUIT
MANHOLE, INLET, OR JUNCTION
CHANNEL OR CONDUIT DESIG
CITY LIMITS
COUNTY (METRO) BOUNDARY
LEVEE

CULVERT
HOLDING POND OR LAKE

N

1/2 1/4 0 1
MILES
1000 500 0 4000
FEET

NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

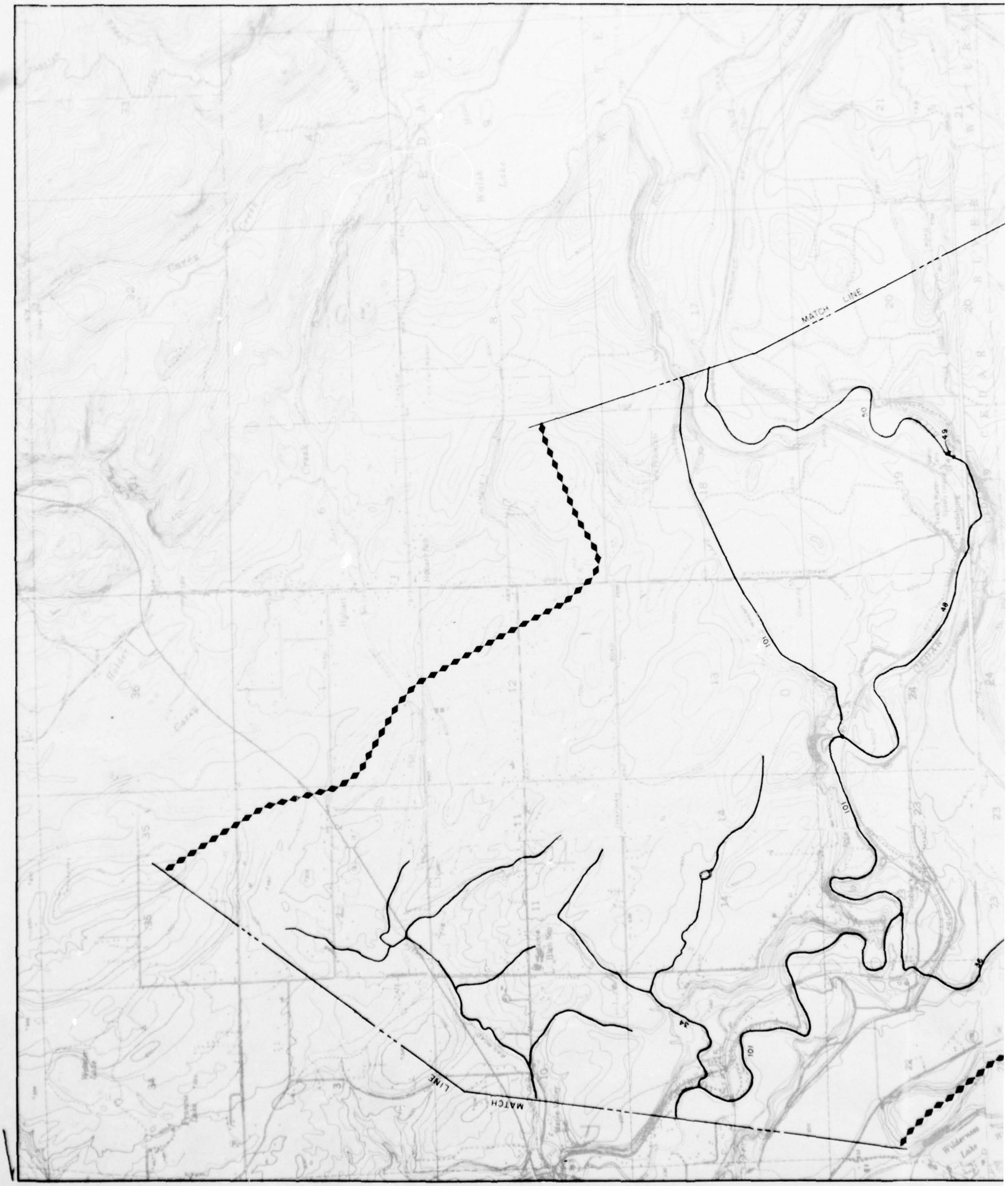
LOWER CEDAR RIVER

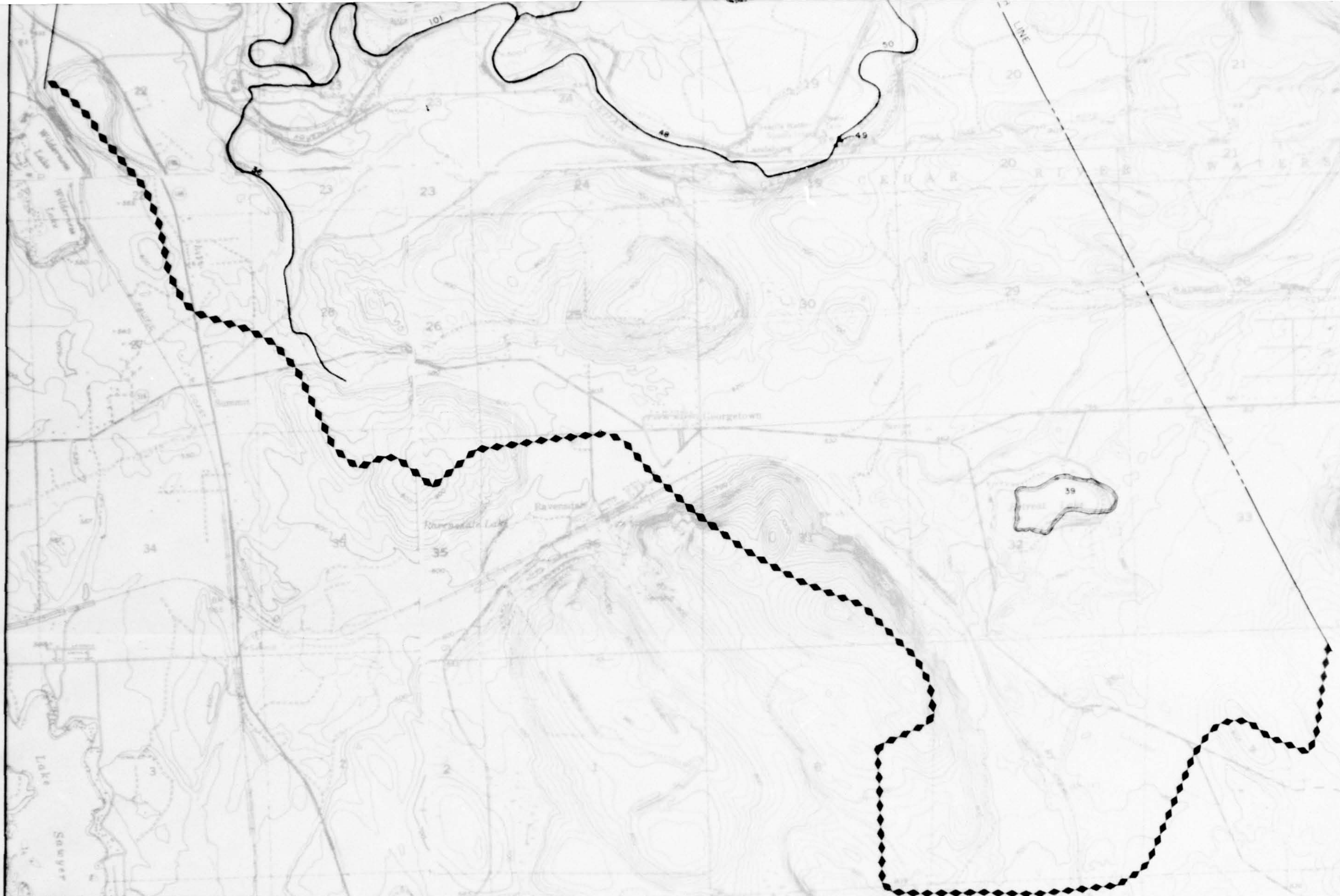
PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

KRAMER, CHIN AND MAYO, INC
WATER RESOURCES ENGINEERS, INC
YODER, TROTTER, ORLOB & ASSOCIATES

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO E-26-1-161 SHEET 2 OF 4


MATCH LINE
MATCH LINE
101
101
101
CEDAR
Walsh Lake
Wilderness Lake
50
49
48
34
36



LEGEND

SUB-BASIN BOUNDARY
EXISTING CHANNEL
EXISTING CONDUIT
MANHOLE, INLET, OR JUNCTION
CHANNEL OR CONDUIT DESIG — 5
CITY LIMITS
COUNTY (METRO) BOUNDARY
LEVEE

CULVERT
HOLDING POND OR LAKE

N

1/2 — 1/4 — 0 — 1
MILES
1000 — 500 — 0 — 4000
FEET

NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

LOWER CEDAR RIVER

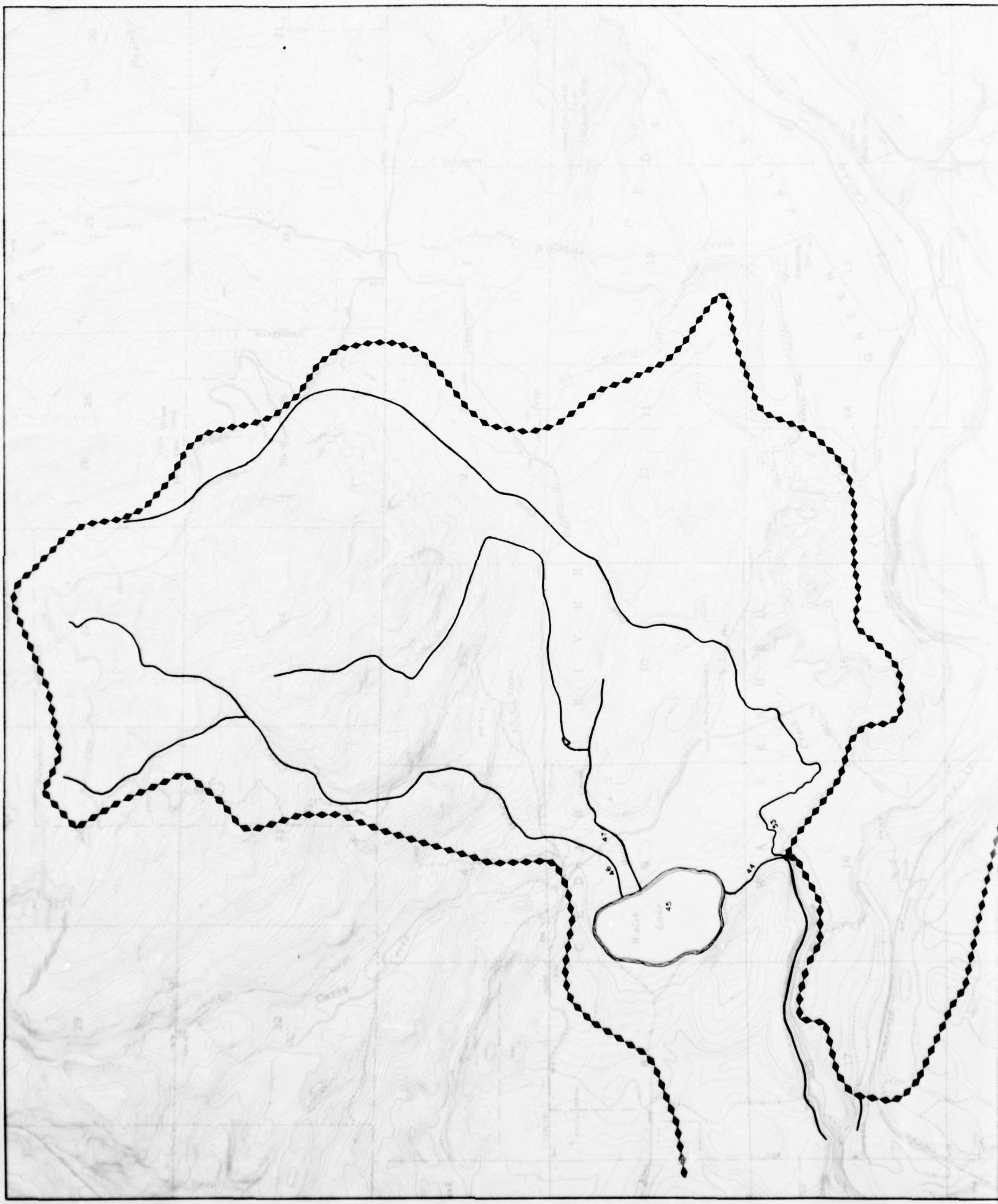
PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

KRAMER, CHIN AND MAYO, INC.
WATER RESOURCES ENGINEERS, INC.
YODER, TROTTER, ORLOB & ASSOCIATES

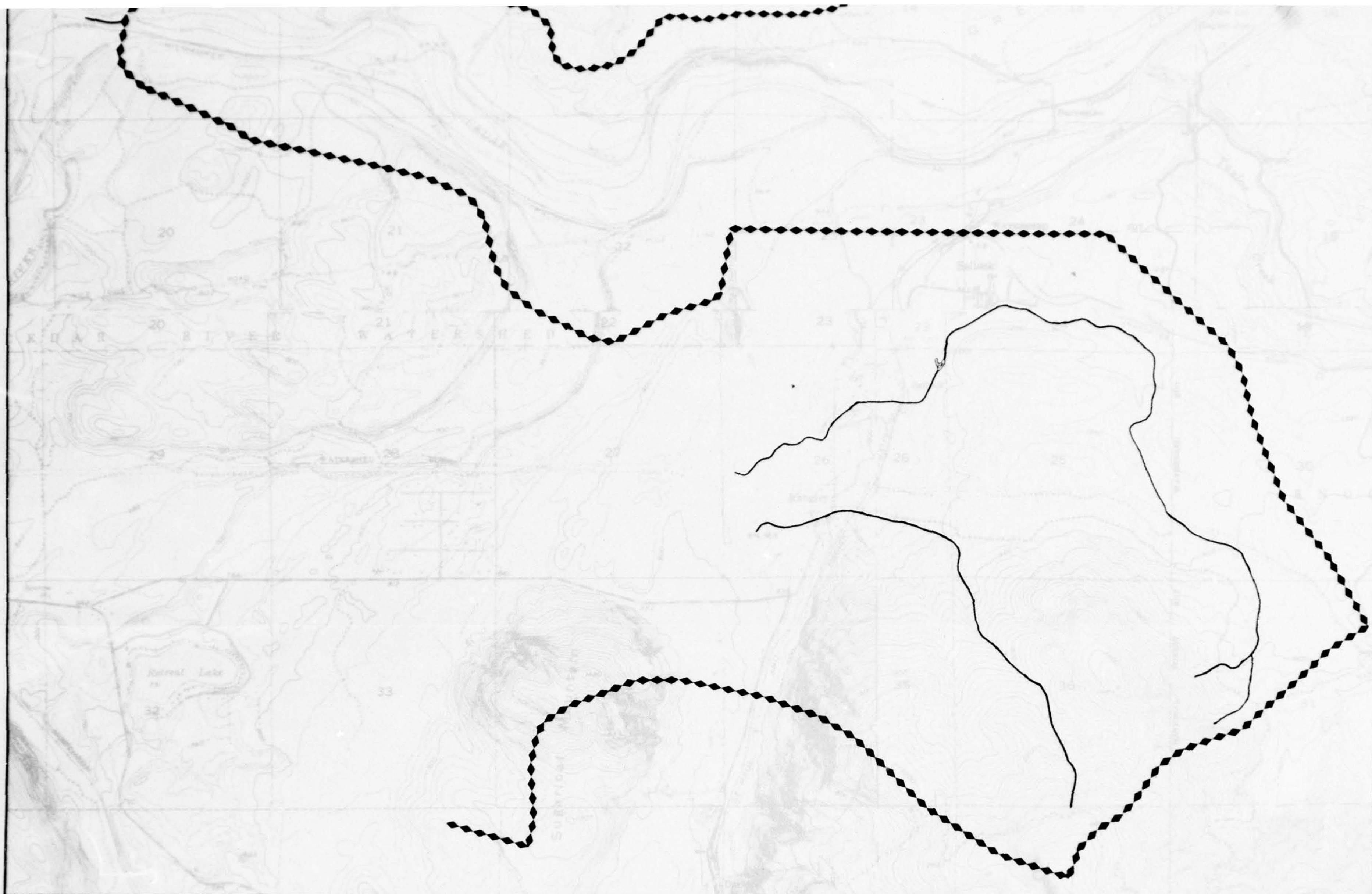
U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO. E-26-1-161 SHEET 3 OF 4

2



47
48
53
44
45



LEGEND

- SUB-BASIN BOUNDARY
- EXISTING CHANNEL
- EXISTING CONDUIT
- MANHOLE, INLET, OR JUNCTION
- CHANNEL OR CONDUIT DESIG. 5
- CITY LIMITS
- COUNTY (METRO) BOUNDARY
- LEVEE
- CULVERT
- HOLDING POND OR LAKE

N

MILES: 1/2, 1/4, 0, 1

FEET: 1000, 500, 0, 4000

NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

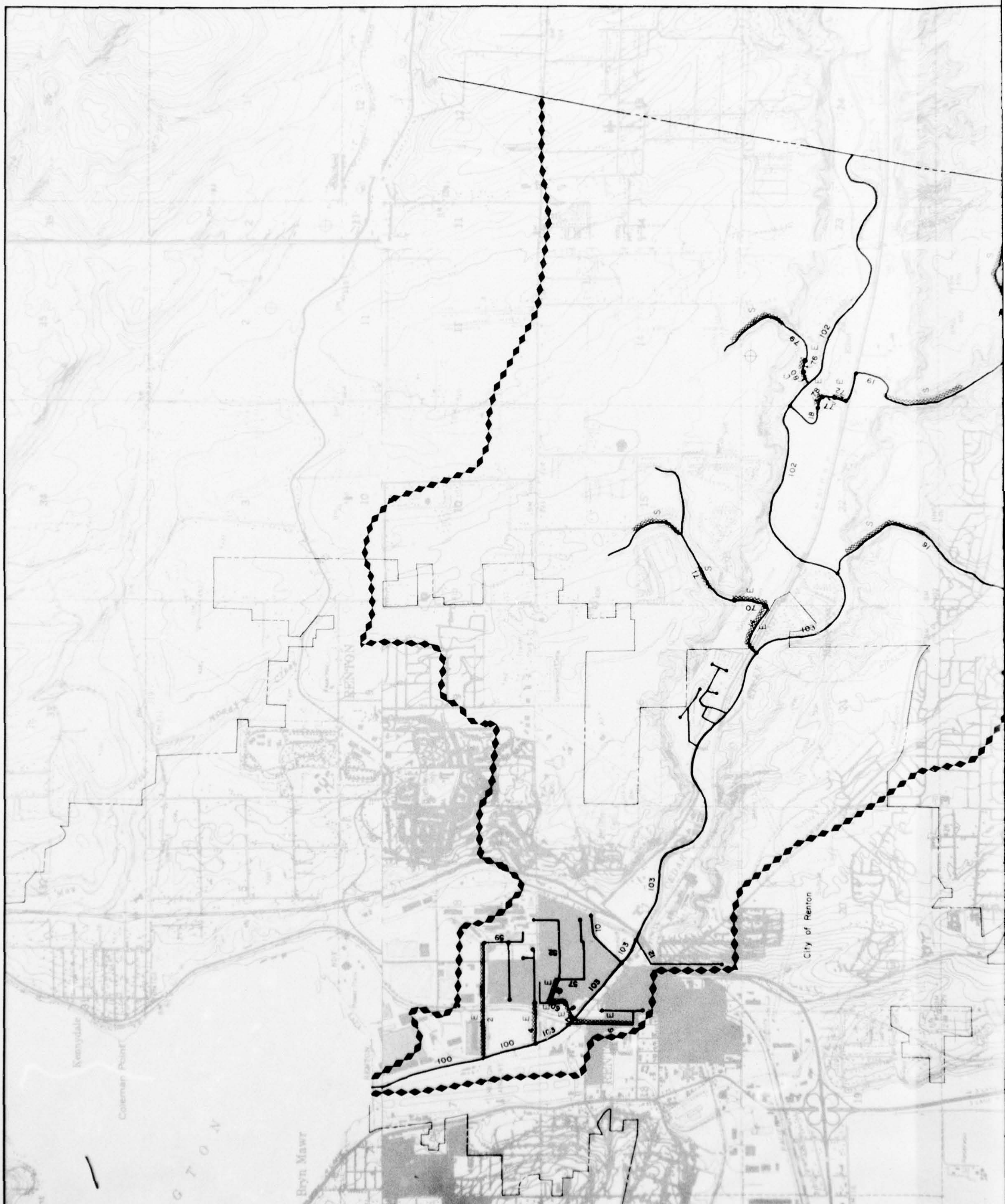
LOWER CEDAR RIVER

PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

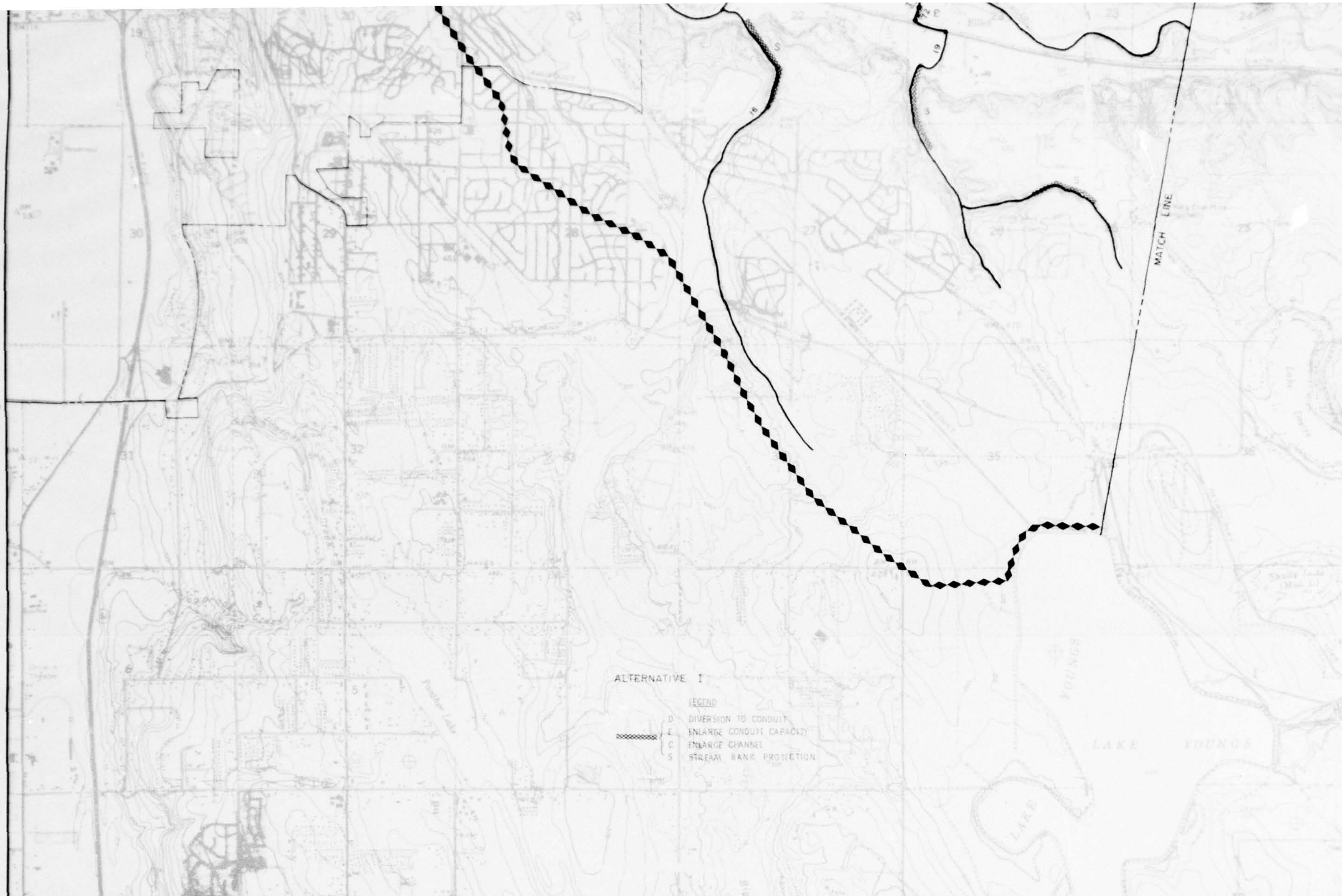
KRAMER, CHIN AND MAYO, INC.
WATER RESOURCES ENGINEERS, INC.
YODER, TROTTER, ORLOB & ASSOCIATES

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO. E-26-1-161 SHEET 4 OF 4



RENTON
City of Renton
CEDAR
Bryn Mawr
Coleman Point
Kennydale



LEGEND

SUB-BASIN BOUNDARY
EXISTING CHANNEL
EXISTING CONDUIT
MANHOLE, INLET, OR JUNCTION
CHANNEL OR CONDUIT DESIG. 5
CITY LIMITS
COUNTY (METRO) BOUNDARY
LEVEE

CULVERT
HOLDING POND OR LAKE

N

1/2 1/4 0 1
MILES
1000 500 0 4000
FEET

NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

LOWER CEDAR RIVER

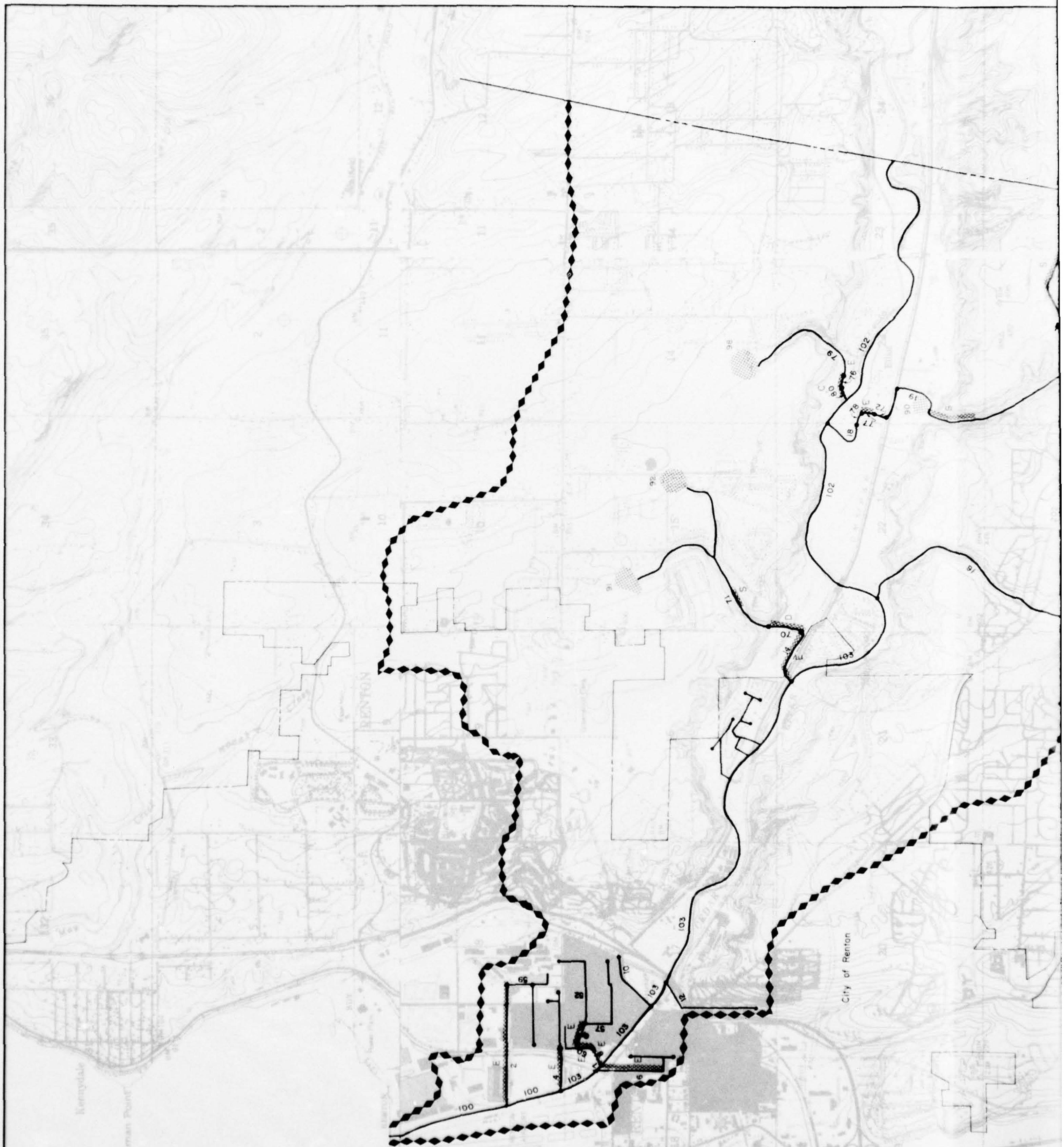
PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

KRAMER, CHIN AND MAYO, INC.
WATER RESOURCES ENGINEERS, INC.
YODER, TROTTER, ORLOB & ASSOCIATES

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO. E-26-1-161 SHEET 1b OF 4

2


City of Renton
RENTON
Kennydale
Coleman Point
Bryn Mawr

LEGEND

- SUB-BASIN BOUNDARY
- EXISTING CHANNEL
- EXISTING CONDUIT
- MANHOLE, INLET, OR JUNCTION
- CHANNEL OR CONDUIT DESIG. 5
- CITY LIMITS
- COUNTY (METRO) BOUNDARY
- LEVEE
- CULVERT
- HOLDING POND OR LAKE

N

1/2 1/4 0 1 MILES

1000 500 0 4000 FEET

NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

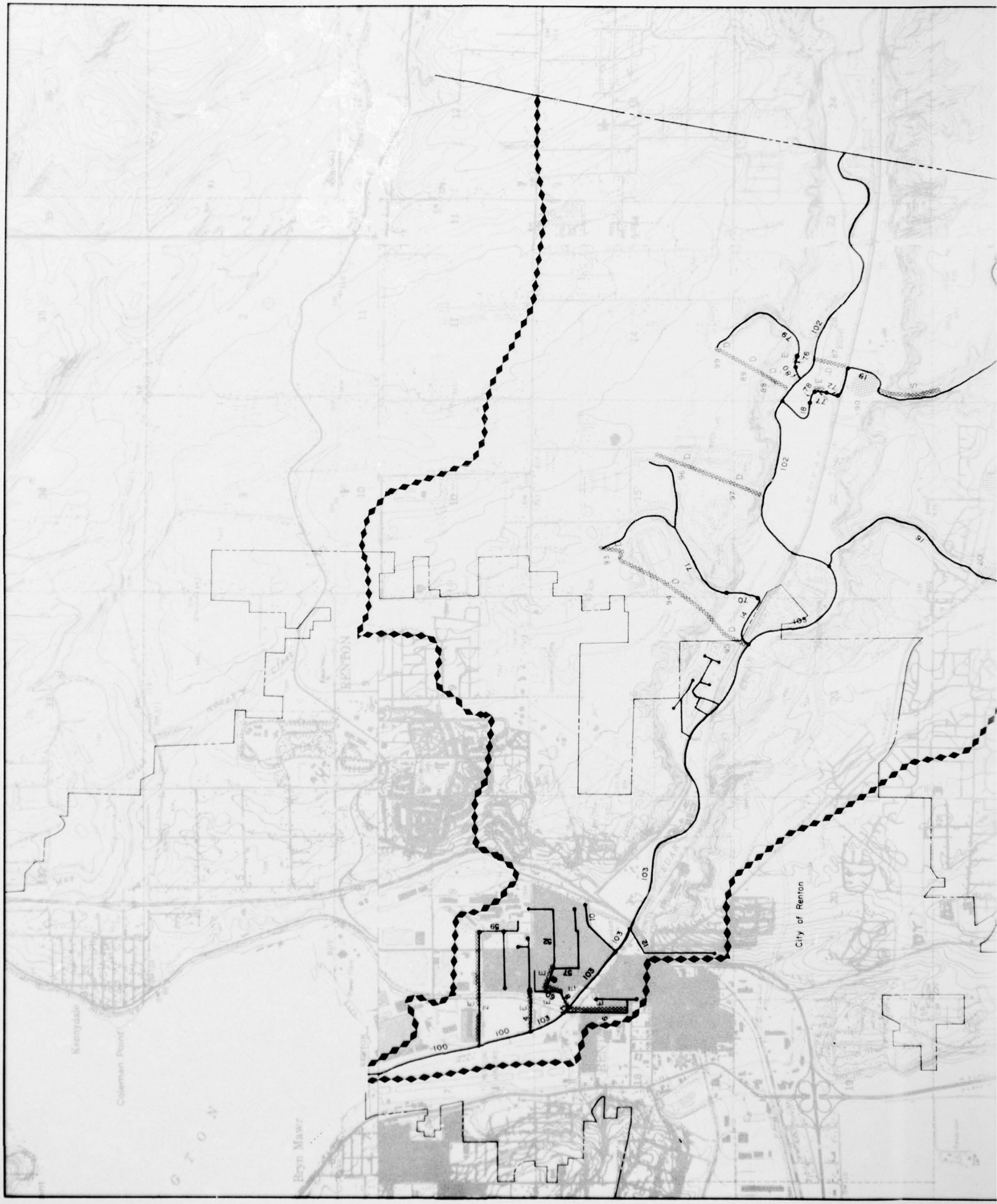
LOWER CEDAR RIVER

PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

KRAMER, CHIN AND MAYO, INC
WATER RESOURCES ENGINEERS, INC
YODER, TROTTER, ORLOB & ASSOCIATES

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO E-26-1-161 SHEET 1E OF 4


RENTON
City of Renton
CEDAR
Kennydale
Coleman Point
Bryn Mawr

1

LEGEND

SUB-BASIN BOUNDARY
EXISTING CHANNEL
EXISTING CONDUIT
MANHOLE, INLET, OR JUNCTION
CHANNEL OR CONDUIT DESIG. 5
CITY LIMITS
COUNTY (METRO) BOUNDARY
LEVEE
CULVERT
HOLDING POND OR LAKE

N

MILES: 1/2 1/4 0 1
FEET: 1000 500 0 4000

NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

LOWER CEDAR RIVER

PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

KRAMER, CHIN AND MAYO, INC
WATER RESOURCES ENGINEERS, INC
YODER, TROTTER, ORLOB & ASSOCIATES

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO. E-26-1-161 SHEET 1[illegible] OF 4

REGIONAL SUB-BASIN C-3

ISSAQUAH CREEK

GENERAL DESCRIPTION

Issaquah Creek, which is about ten miles long, drains forested foothills of the Cascade Range and empties into Lake Sammamish on the southern extremity. The two primary topographic features of the sub-basin are Tiger Mountain, which lies east of the main channel and rises to an elevation of 2,900 feet, and Squak Mountain, which lies to the west of the main stream and rises to a height of 2,000 feet. Issaquah Creek flows in the valleys between these two mountains with smaller streams entering the main channel at various points. South of Lake Sammamish, the land flattens out to form the Issaquah Creek flood plain.

The physical characteristics of the major tributaries to Issaquah Creek are noted below:

Stream	Category	Drainage Area	Point of Discharge
North Fork of Issaquah Creek	II	4.3 sq. mi.	Issaquah Creek
East Fork of Issaquah Creek	II	8.5 sq. mi.	Issaquah Creek
Holder Creek	I	6.7 sq. mi.	Issaquah Creek
Fifteen Mile Creek	I	5.0 sq. mi.	Issaquah Creek
Carey Creek	I	7.3 sq. mi.	Issaquah Creek

Land in the sub-basin is largely undeveloped with the City of Issaquah being the greatest population center. Residential developments include those on the north and south faces of Squak Mountain, on the west side of South Tiger Mountain, and on the ridge north of the City of Issaquah. Outside of these residential developments, single-family units are generally widely dispersed. Future growth will most likely follow present trends, with the major residential areas remaining in the northern portion of the sub-basin. Present indications are that a large commercial and industrial community will engulf the low lying area along the I-90 corridor between the flood plains of Issaquah Creek and Tibbetts Creek. Present and projected land use is presented on the next page.

PERCENT OF SUB-BASIN AREA IN SPECIFIED LAND USE

Land Use	Existing (1970-72)	P.S.G.C. Land Use Projection Comprehensive	Corridor
Single Family	5	15	15
Multiple Family	<1	1	1
Commercial/Services	<1	1	1
Govt. and Educ.	1	1	1
Industrial	<1	2	2
Parks/Dedicated Open Space		5	5
Agriculture	15	10	10
Airports, Railyards Freeways, Highways	<1	<1	<1
Unused Land	77	64	64
Water	<1	<1	<1
Total	100	100	100
Total Impervious Area	5	10	10

Most of this sub-basin is in King County, outside the jurisdiction of any city. The one major exception to this is the City of Issaquah and its watershed that lies due west of the city, including Tradition Lake. Approximately 15% of the sub-basin is within the jurisdiction of the City of Issaquah with the remaining 85% lying within King County. The City of Issaquah is the only portion of the sub-basin that lies within the Metro service area.

NATURE OF EXISTING DRAINAGE SYSTEM

Issaquah Creek and its tributaries are well defined, although overgrown with small trees and brush in many places. The streams follow natural channels except where they have been altered to accommodate roadways, and are generally in a natural condition, except where residential development in Issaquah and surrounding developments have encroached upon the banks. The main channel of Issaquah Creek meanders through the City of Issaquah where it has been incorporated into neighborhood landscapes and plays an integral part in the city drainage system. The further upstream one travels, the less encroachment can be found, and at the source of Holder and Carey Creeks the land is totally undeveloped.

Issaquah Creek is considered a valuable fisheries resource and supports an annual run of chinook and coho salmon. The State Department of Fisheries operates a fish hatchery on the main channel of the creek within the city limits of Issaquah.

DRAINAGE PROBLEMS

Most of the problems found in this sub-basin are in the vicinity of the City of Issaquah. Flooding, erosion, sedimentation, and debris-deposits along the main channel of Issaquah Creek have caused problems for individuals and the community as a whole. Urbanization of Squak Mountain has increased the rate of runoff in the portion of the creek that passes through Issaquah, and a newly-constructed bridge within the city limits has caused a constriction that creates backup and subsequent roadway-flooding during heavy rains.

Urban growth also has taken its toll along the North Fork of Issaquah Creek. It causes greater flows than would be expected in natural conditions, with erosion of hillsides and subsequent delta formation.

In the undeveloped portions of the sub-basin, particularly the southern end, concerns are primarily with debris deposits carried downstream during heavy rains and the natural erosion that occurs in the wet winter months.

In terms of water quality, the Issaquah Creek Sub-Basin is generally considered good. However, there are two significant problems that should be considered in future planning; leachate draining into the main channel of Issaquah Creek from the Cedar Hills landfill, and sediment released from the gravel pit north of the I-90 corridor during periods of heavy rainfall. An EPA Grant has been prioritized by DOE for King County to pump the leachate to the Metro sewer system.

One of the newly emerging problems in this sub-basin comes as a result of urbanization. Development is proceeding at a rapid rate in the southwest quarter of Issaquah, with little consideration being given proper drainage. Runoff flows through open roadside ditches, and both erosion and downstream sedimentation, are becoming serious. Similar activities are occuring elsewhere, but not with the same intensity.

Another future problem that has received considerable attention concerns construction of I-90 east of Issaquah. The major impact of this work will be on the East Fork of Issaquah Creek and means are now being developed by the Highway Department, in cooperation with the State Department of Fisheries, to see that the creek is preserved and that the salmon run is maintained.

Both the year 2000 Comprehensive and Corridor land use plans project an increase in impervious land area within the sub-basin from an existing 5% to approximately 10%. While this represents a sizable increase over existing land use, the level of development will be far behind that experienced

in the more urban sub-basins of the Puget Sound Region and should allow Issaquah Creek to continue as the main carrier of storm water runoff.

The results of hydrologic analysis indicate no significant difference between the Comprehensive and Corridor Land Use Plans. Therefore, the drainage alternatives presented herein are applicable to both plans.

BASIC ISSUES AND STATUS OF DRAINAGE PLANNING

As part of the RIBCO planning effort, numerous public meetings were conducted throughout the Cedar and Green River basins to obtain public input as to local problems and concerns. Engineering alternatives were presented at these meetings and comments were solicited regarding the acceptability of the various solutions. These comments were then considered in developing solutions and alternative plans as presented below. A special meeting was not conducted within the Issaquah Creek Sub-Basin however.

A special flood-hazard information report for Issaquah and Tibbetts Creeks was prepared by the Corps of Engineers in 1971 by request of the Washington State Department of Ecology. The report contains aerial maps and water-surface profiles that indicate the extent of probable flooding in the Issaquah area for an eight-mile reach of Issaquah Creek, and the lower one mile of the North and East Forks of Issaquah Creek. The report concluded that zoning should be utilized to select appropriate use for flood-prone areas, and that a floodway should be established that would be maintained free of obstructions and have capacity to pass the selected flood. Developments will be allowed in the floodway fringe only, provided they comply with certain regulatory controls regarding minimum floor elevations and flood-proofing provisions.

The City of Issaquah has recognized the problems associated with Issaquah Creek and recently established a Flood Hazard Zone within the city limits that requires building setbacks and building-height limitations along the creek.

Other planning efforts in this sub-basin include a Comprehensive Land Use Plan being prepared by the Issaquah Planning Department for flood control, King County's 1964 Comprehensive Plan and an Urban Trails Plan completed in 1971 that shows a system of trails in the Issaquah Valley.

To date there is no coordinated effort between King County and the City of Issaquah to arrive at any solutions to drainage problems in this sub-basin.

Staff members from King County Public Works Department, Hydraulics Division, have reviewed the initial alternative plans for drainage developed by this RIBCO Study for Issaquah Creek.

ALTERNATIVE PLANS FOR PROPOSED DRAINAGE CONTROL

The existing drainage system of Issaquah Creek Sub-Basin, as described by local agencies, was evaluated by computer simulation that applied the region's 10 year storm to P.S.G.C. year 2000 land use. Drainage problems thus identified were analyzed and possible solutions were provided in the development of alternative plans for drainage control as described below.

ALTERNATIVE PLAN I

General Concept

The alternative calls for increasing the size of surcharged channels, construction of storm sewers in areas requiring a planned drainage system, and protection of natural streams when such work would be necessary to control erosion.

Major Features

The most significant single element of this plan is a storm trunk system proposed within the City of Issaquah to serve the Wildwood and Mountain Park developments. Such a system would reduce erosion in the roadside ditches and prevent other runoff related damage.

Also included in this alternative is protection of a portion of the North Fork of Issaquah Creek just upstream from East Sammamish Road which would involve rip-rap in selected areas that are now subject to scouring and drop structures positioned to reduce velocities. In the past, the North Fork created flooding problems in the area adjacent to I-90, but in recent months new culverts were installed that alleviate much of the problem, and in the near future more construction is planned to increase the capacity of the channel itself.

Some channel improvements are recommended for the area where Issaquah Creek passes through the Sycamore development in the south end of the city. Channel modifications sufficient to pass the 10-year storm would be minimal, primarily entailing the flattening of channel banks. To pass more severe storms, however, channel sizes would need to be enlarged.

Cost

The cost for Alternative Plan I is estimated to be $500,000.

ALTERNATIVE PLAN II

General Concept

An alternative to a strictly conventional storm sewer in this sub-basin is the concept of detention storage and controlled release. This technique is most applicable in the area north of I-90 that is tributary to

the North Fork of Issaquah Creek. Storage on a large scale may not be applicable in other, steeper areas in the sub-basin, although many small storage areas in residential developments would perform the same function. Where large-scale storage is not available, this alternative considers only the storm sewer solution such as in the case of Wildwood and Mountain Park in Issaquah. In presently unplatted and undeveloped areas, small holding ponds should be considered before new construction is permitted.

Major Features

As with Alternative Plan I, this plan includes a storm trunk sewer to serve the newly developed residential areas in Issaquah. However, instead of extensive erosion-control facilities on the portion of the North Fork of Issaquah Creek just upstream from I-90, a large storage pond is proposed with a volume of approximately 18 acre feet and a release rate of 20 cubic feet per second. This would result in creek flows similar to what might be expected if the sub-basin were totally undeveloped.

Included in this plan are channel improvements along Issaquah Creek in the vicinity of the south city limits as previously described.

Cost

The cost of Alternative Plan II is estimated to be $500,000.

PEAK FLOW COMPARISONS

The following table indicates 10-year peak flows with existing facilities and with alternative drainage management solutions for the year 2000. The peak flows are given for location as indicated, as well as at the point of discharge into Lake Sammamish.

COMPARISON OF 10-YEAR PEAK FLOWS
(Cubic Feet per Second)

Location	Existing Facilities	Alternative Plan I	Alternative Plan II
Clark Street Bridge	1,000	1,000	1,000
East Fork at Main Channel	300	280	280
North Fork at Main Channel	200	200	100
Lake Sammamish	1,500	1,425	1,425

ENVIRONMENTAL ASSESSMENT OF ALTERNATIVE PLANS

Field inspections were made to determine the applicability of the suggested alternative plans for this sub-basin. This process was followed throughout the RIBCO Study in developing alternative plans for the various

regional sub-basins. The inspections were based on the alternative evaluation procedure which identified 34 unique criteria grouped in general categories as follows: 1) Effectiveness, 2) Human Values, 3) Environmental Factors, 4) Implementation, and 5) Resource Requirements. The various structural solutions were checked against the appropriate criteria and the various non-structural solutions were reviewed for their relationship to existing and probable future developments. The criteria rating total for Alternative Plan I, which employs channelization, diversion and minor streambank protection, was a plus 14 on a scale ranging from a positive total of 108 to a negative total of 108. The total evaluation rating for Alternative Plan II, which employs storage, channelization, and diversion, was also a plus 14.

Both alternative plans were judged to be generally equal due to the limited amount of storage available in the sub-basin. Both alternatives registered positive ratings for effectiveness and both preserved human values to a small degree. Neither alternative is believed to significantly alter environmental factors and neither alternative has any significant resource requirement. Because of the coordination between King County and the City of Issaquah that would be necessary to implement either alternative, both alternatives are judged to be equally difficult for implementation. Neither alternative should affect the fishery potential of Issaquah Creek.

Because the two alternative plans rely upon relatively modest structural solutions to solve future runoff problems, there does not appear to be a great urgency for implementation of any element contained within the plans. Probably more significant than any future problems that may arise in the sub-basin, is the treatment given to the I-90 construction work now in progress within the sub-basin and the alleviation of sedimentation/siltation runoff from existing gravel pits. Fortunately, the Issaquah Creek Sub-Basin is not expected to realize rapid urbanization and the stream should be able to accommodate future growth with relatively minor alterations.

CONCLUSIONS

There is no clearly superior alternative for this sub-basin. The proposed methods of accommodating projected future storm runoff in either alternative plan are similar enough so that there appears to be no need for immediate action.

King County and the City of Issaquah should establish an effective agreement, however, for development of a master drainage plan. Both agencies would then need to move to implement the master plan within their own jurisdictions. The basic issue appears to be which agency or agencies will have jurisdiction and overall responsibility for control of urban drainage and related flood damage problems. While the largest portion of the sub-basin lies within King County, the City of Issaquah is projected to have the most runoff problems. King County should have responsibility for control of drainage and flood damage within the Issaquah Creek Sub-Basin, and the City of

Issaquah and King County should exercise control of zoning, including flood plain zoning, within their respective boundaries and concurrent jurisdiction in outer fringe areas of the City. This may require some amendments to State laws and local ordinances.

RUNOFF QUALITY SUMMARY
ISSAQUAH CREEK

BASED UPON A 10-YEAR STORM PRECEDED BY 15 DAYS WITH LITTLE OR NO RAINFALL#

			CONCENTRATION AT PEAK FLOW*				
LOCATION	ALTERNATIVE PLAN	PEAK FLOW (cfs)	BOD	TOTAL COLIFORM	NH_3	$NO_2 + NO_3$	PO_4
Mouth	I & II**	1425	.8	1.9×10^4	.03	.3	.05

Less than a total of 0.5 inches of rainfall in any one day.
* Concentrations in mg/liter except total coliform which is in MPN/100 ml.
** Alternative plans effect water quality equally.

EVALUATION MATRIX

ISSAQUAH CREEK

		EFFECTIVENESS									HUMAN VALUES								ENVIRONMENTAL FACTORS										IMPLEMENTATION							RESOURCE REQUIREMENTS				
		Use of existing facilities	System reliability	System maintainability	System flexibility	Flood damage reduction	Consequences of overcharge	Erosion and sedimentation control	Cost/benefits ranking		Urban quality (aesthetics)	Effect on land use	Displacement of people	Educational value	Community cohesion	Multiple use potential	Public health and safety		High flow conditions	Alteration of natural system	Effects on groundwater	Low flow conditions	Water quality	Construction disruption	Effects on wildlife	Effects on aquatic life	Effects on vegetation		Legislative requirements	Jurisdictional	Land acquisition	Public acceptance	Financing	Effects of no action		Energy	Materials	Land	Capital	RATING TOTAL
ALTER-NATIVES	SUB TOTAL	CRITERIA WEIGHT								SUB TOTAL	CRITERIA WEIGHT							SUB TOTAL	CRITERIA WEIGHT									SUB TOTAL	CRITERIA WEIGHT						SUB TOTAL	CRITERIA WEIGHT				
		1	4	3	2	4	4	4	2		4	2	2	1	3	3	4		4	4	4	4	4	2	4	4	4		4	4	2	4	4	3		3	3	2	2	
I	+11									+4								0										-1							0					+14
II	+11									+4								0										-1							0					+14

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative I Sub-Basin Issaquah Creek

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
201	None					Diversion Pipe	18" 1,300'	$39,000
202	None					Diversion Pipe	21" 2,800'	$101,000
203	None					Diversion Pipe	24" 1,000'	$42,000
204	None					Diversion Pipe	15" 700'	$18,000
205	None					Diversion Pipe	18" 1,500'	$45,000
206	None					Diversion Pipe	24" 3,100'	$130,000
5	Channel	6'	9,300'	2:1	4'	Channel	Streambank protection and drop structures	$20,000
71	Channel	20'	8,400'	1:1	4'	Channel	20' width 4' depth 2:1 side slopes(includes channel cleaning)	$37,000
45	Channel	32'	4,200'	1:1	4'	Channel	32' width 4' depth 2:1 side slopes(includes channel cleaning)	$18,000

The Estimated Capital Cost for each element includes Contractor profit, engineering, legal and contingencies. In addition, land purchase and severance costs are included where land is required. All costs are based upon June 1973 prices.

Total Estimated Capital Cost: $450,000

Round To: $500,000

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

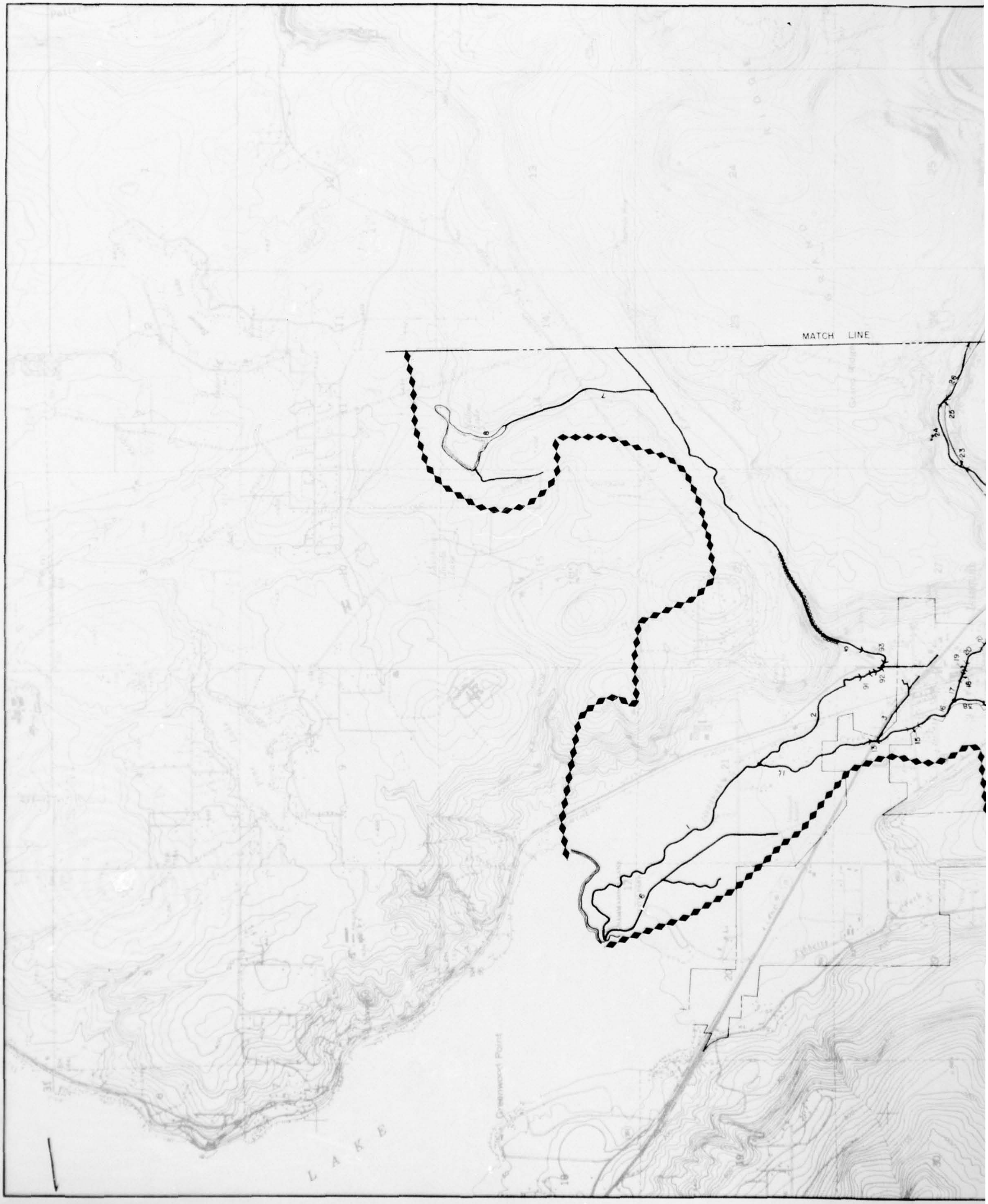
Alternative II Sub-Basin Issaquah Creek

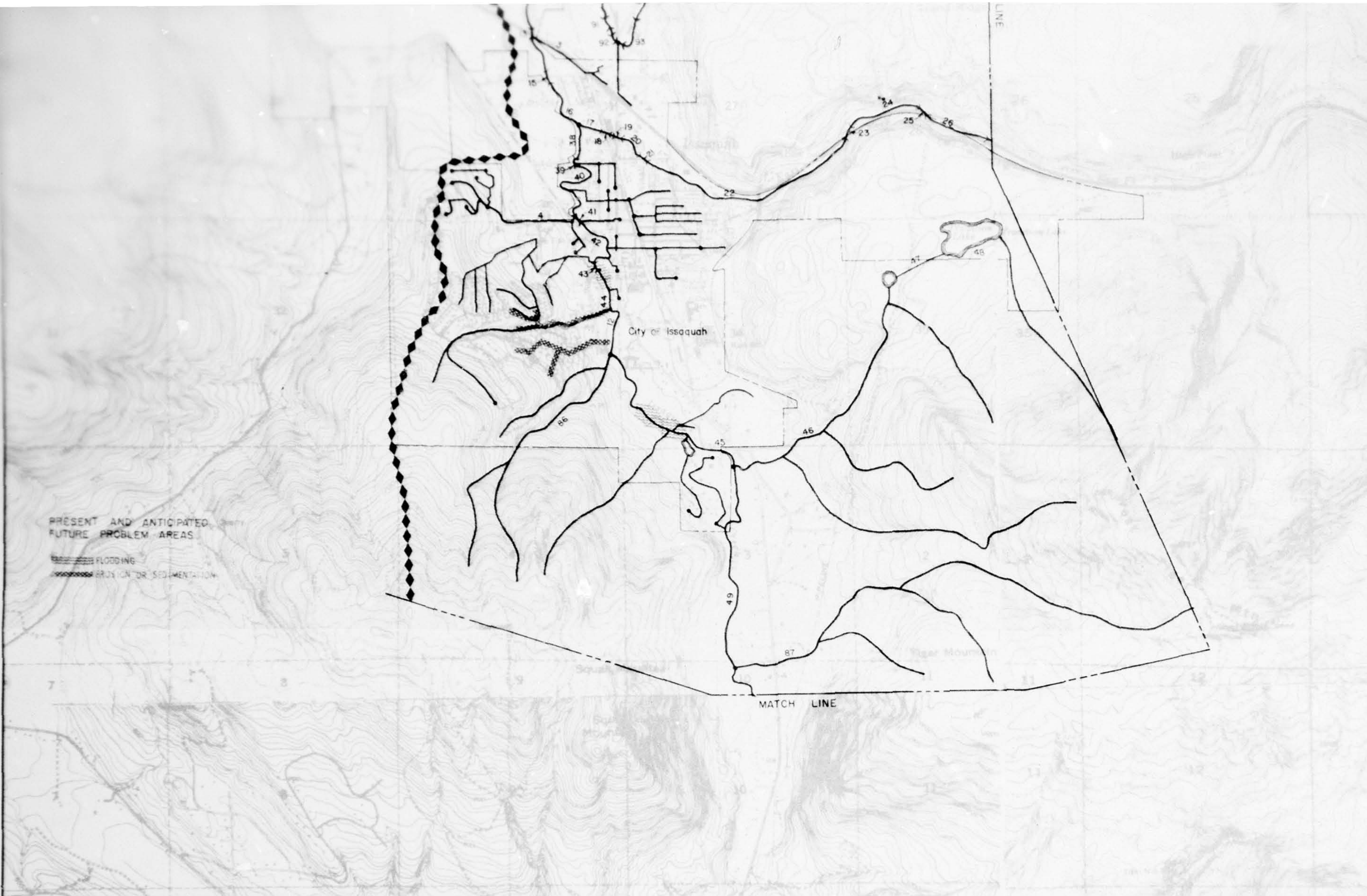
ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
201	None					Diversion Pipe	18" 1,300'	$39,000
202	None					Diversion Pipe	21" 2,800'	$101,000
203	None					Diversion Pipe	24" 1,000'	$42,000
204	None					Diversion Pipe	15" 700'	$18,000
205	None					Diversion Pipe	18" 1,500'	$45,000
206	None					Diversion Pipe	24" 3,100'	$130,000
207	None					Holding Pond	18 AF	$44,000
71	Channel	20'	8,400'	1:1	4'	Channel	20' width 4' depth 2:1 side slopes(includes channel cleaning)	$37,000
45	Channel	32'	4,200'	1:1	4'	Channel	32' width 4' depth 2:1 side slopes(includes channel cleaning)	$18,000

The Estimated Capital Cost for each element includes Contractor profit, engineering, legal and contingencies. In addition, land purchase and severance costs are included where land is required. All costs are based upon June 1973 prices.

Total Estimated Capital Cost: $474,000

Round To: $500,000


MATCH LINE
LAKE
Greenwood Point



LEGEND

SUB-BASIN BOUNDARY
EXISTING CHANNEL
EXISTING CONDUIT
MANHOLE, INLET, OR JUNCTION
CHANNEL OR CONDUIT DESIG. 5
CITY LIMITS
COUNTY (METRO) BOUNDARY
LEVEE

CULVERT
HOLDING POND OR LAKE

N

1/2 1/4 0 1 MILES

1000 500 0 4000 FEET

NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

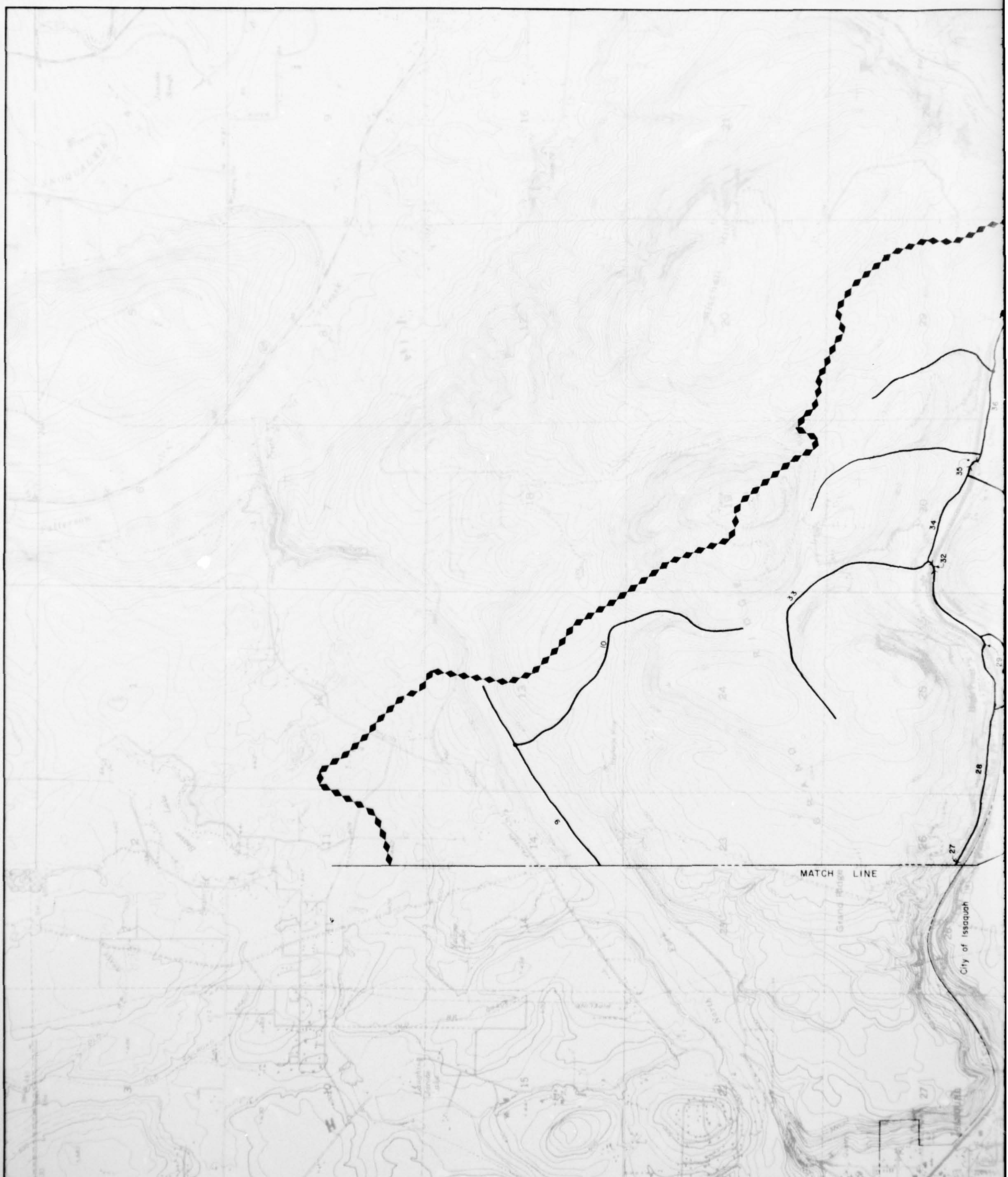
ISSAQUAH CREEK

PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

KRAMER, CHIN AND MAYO, INC.
WATER RESOURCES ENGINEERS, INC.
YODER, TROTTER, ORLOB & ASSOCIATES

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO. E-26-1-161 SHEET 1a OF 4


MATCH LINE
City of Issaquah
Grand Ridge

LEGEND

SUB-BASIN BOUNDARY
EXISTING CHANNEL
EXISTING CONDUIT
MANHOLE, INLET, OR JUNCTION
CHANNEL OR CONDUIT DESIG. 5
CITY LIMITS
COUNTY (METRO) BOUNDARY
LEVEE

CULVERT
HOLDING POND OR LAKE

N

1/2 1/4 0 1 MILES

1000 500 0 4000 FEET

NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

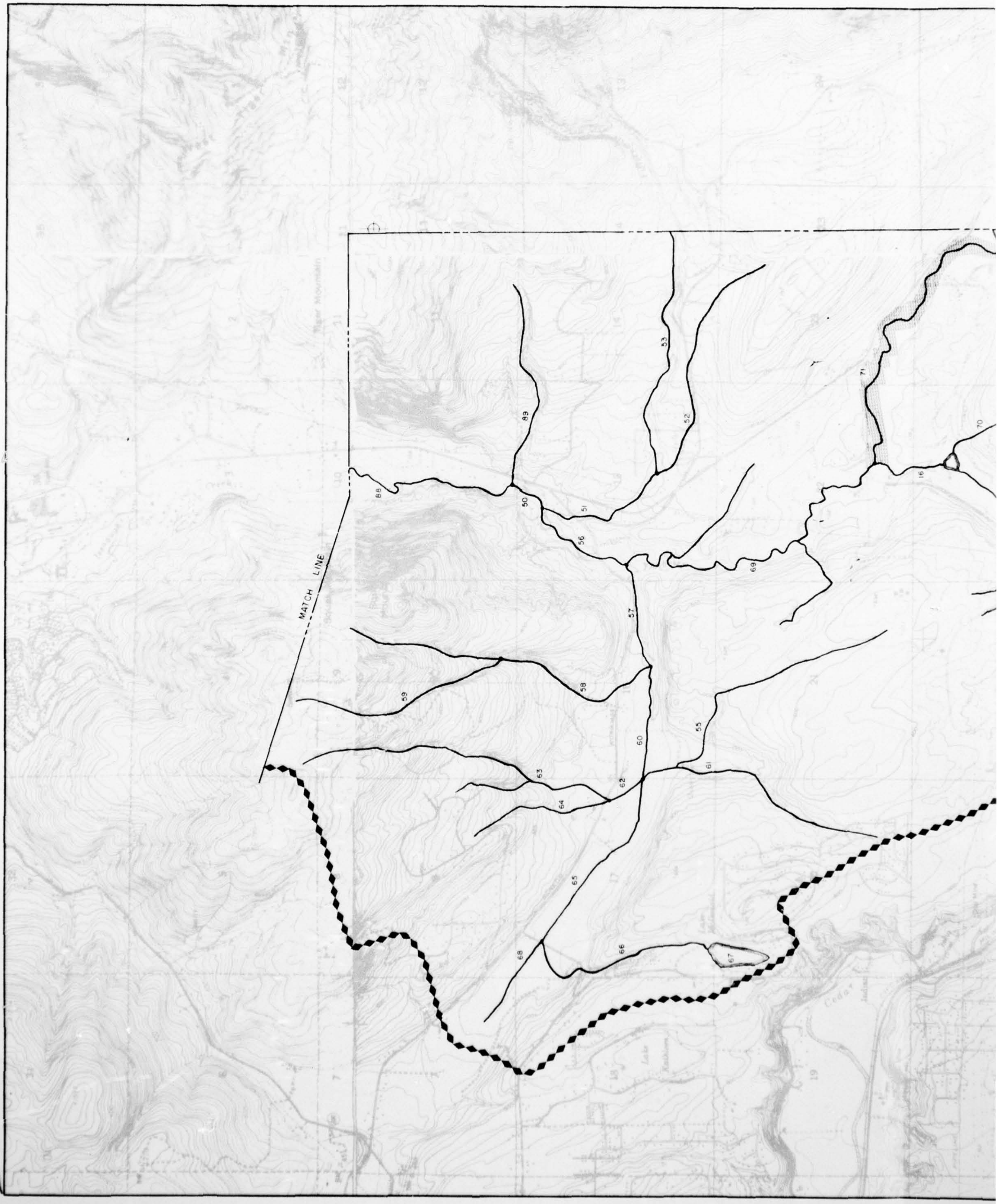
ISSAQUAH CREEK

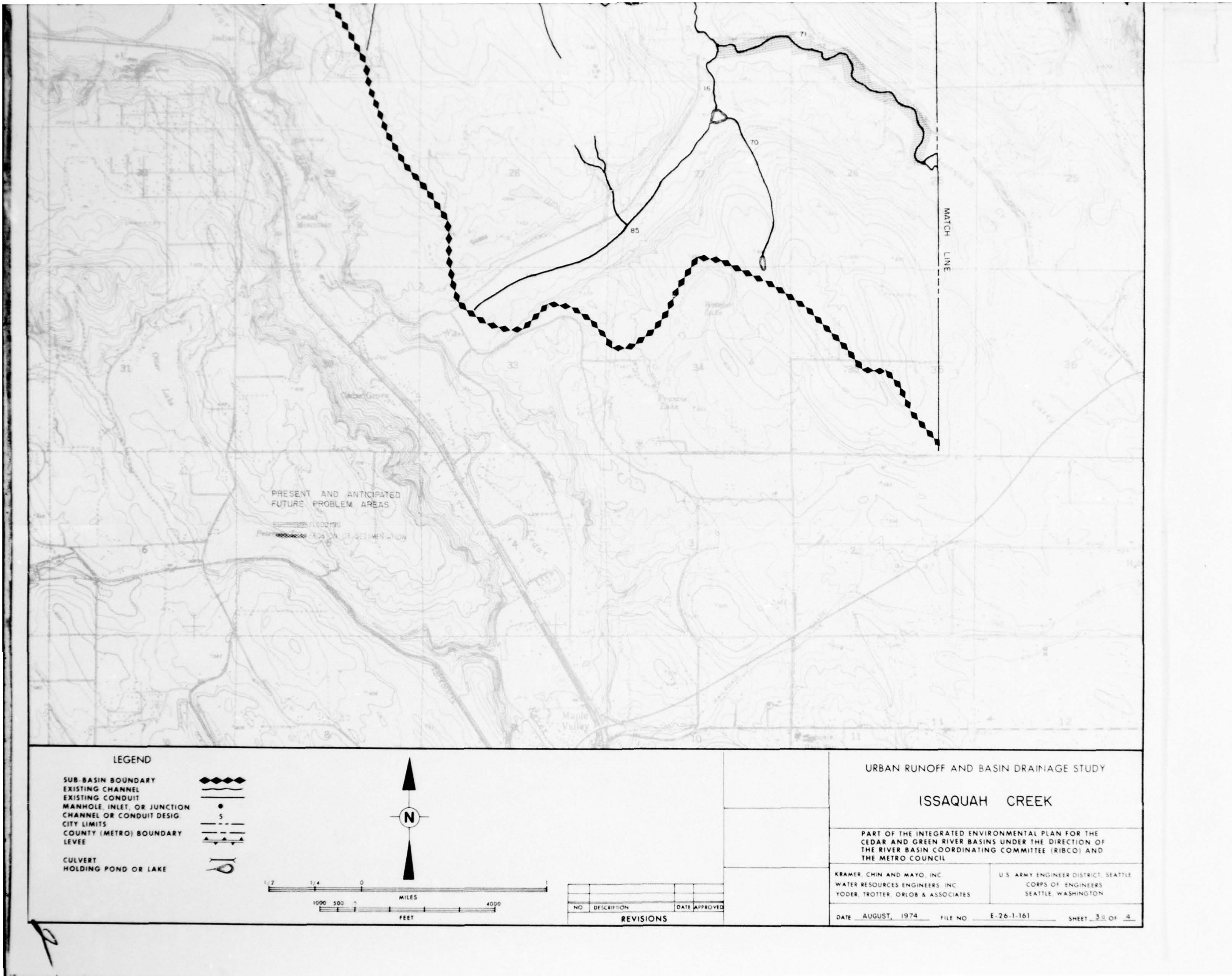
PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

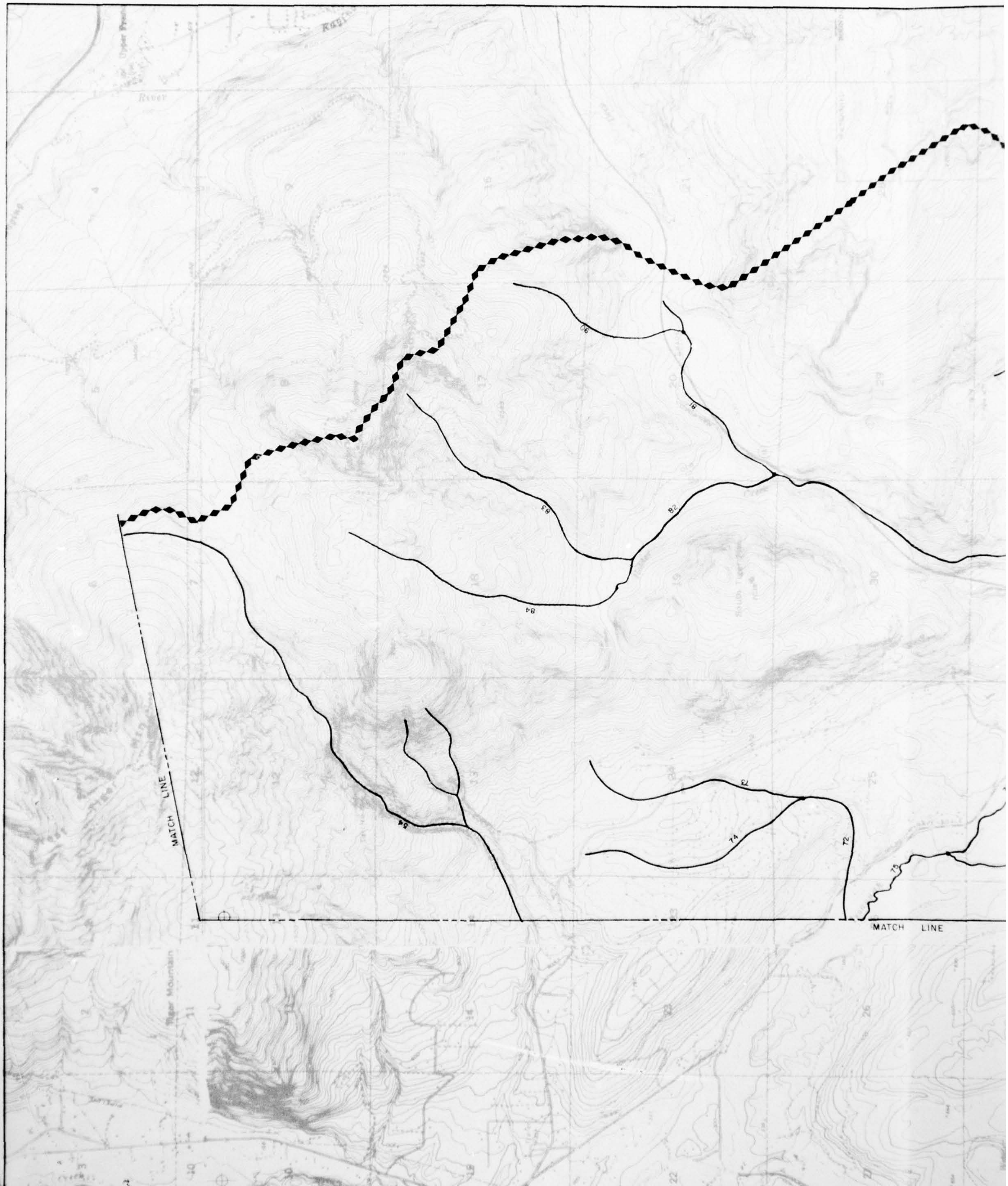
KRAMER, CHIN AND MAYO, INC
WATER RESOURCES ENGINEERS, INC
YODER, TROTTER, ORLOB & ASSOCIATES

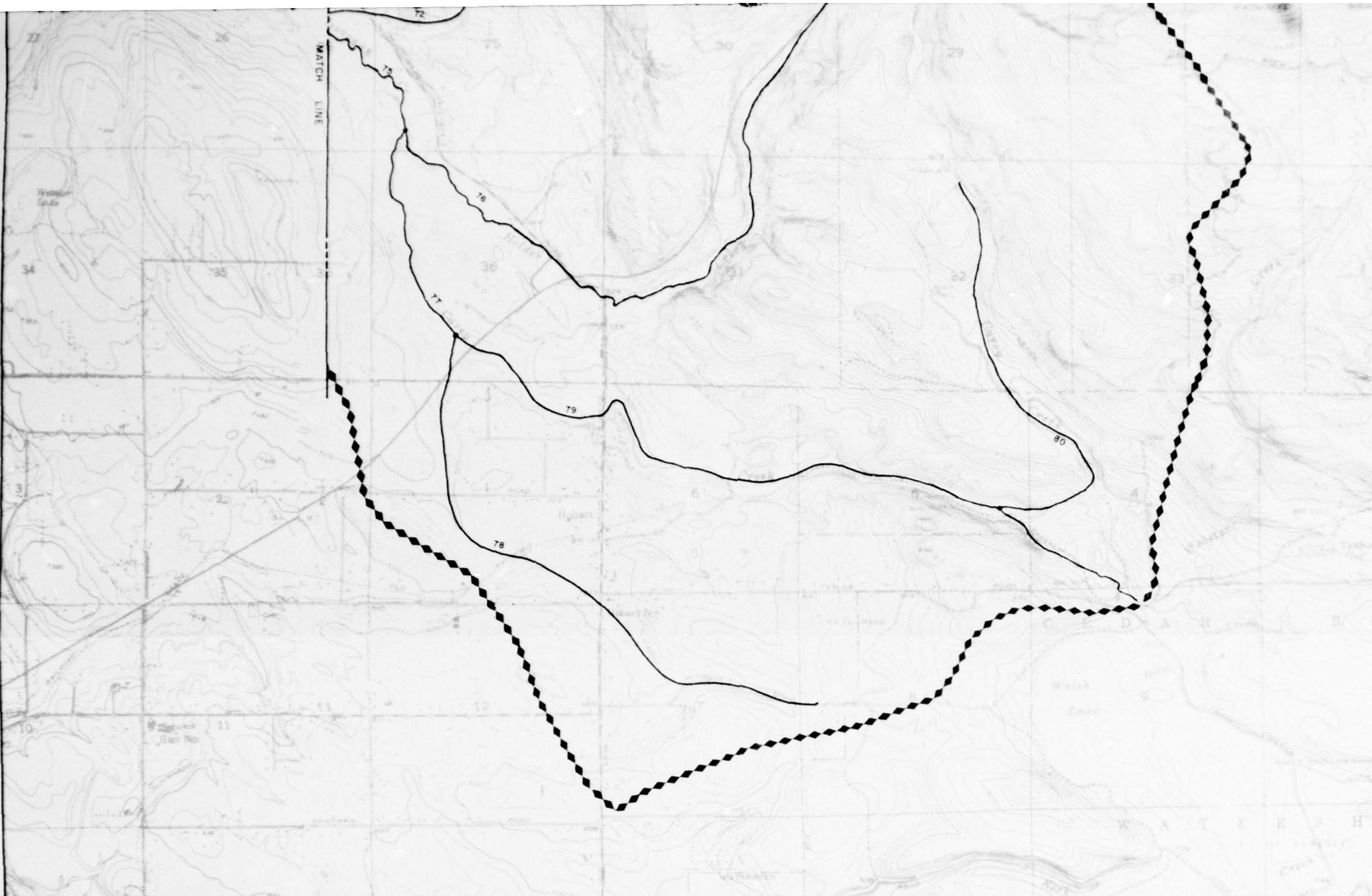
U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO. E-26-1-161 SHEET 2 OF 4


MATCH LINE
88
89
50
51
52
53
56
57
58
59
60
55
61
62
63
64
65
66
67
68
69
70
71


MATCH LINE
71
16
70
85
PRESENT AND ANTICIPATED
FUTURE PROBLEM AREAS
FLOODING
EROSION OR SEDIMENTATION
LEGEND
SUB-BASIN BOUNDARY
EXISTING CHANNEL
EXISTING CONDUIT
MANHOLE, INLET, OR JUNCTION
CHANNEL OR CONDUIT DESIG.
5
CITY LIMITS
COUNTY (METRO) BOUNDARY
LEVEE
CULVERT
HOLDING POND OR LAKE
N
1/2
1/4
0
1
MILES
1000
500
0
4000
FEET
NO
DESCRIPTION
DATE
APPROVED
REVISIONS
URBAN RUNOFF AND BASIN DRAINAGE STUDY
ISSAQUAH CREEK
PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL
KRAMER, CHIN AND MAYO, INC.
WATER RESOURCES ENGINEERS, INC.
YODER, TROTTER, ORLOB & ASSOCIATES
U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON
DATE AUGUST, 1974
FILE NO. E-26-1-161
SHEET 3a OF 4


MATCH LINE
MATCH LINE
90
81
83
82
84
54
73
74
72
75
Bear Mountain



LEGEND

SUB-BASIN BOUNDARY
EXISTING CHANNEL
EXISTING CONDUIT
MANHOLE, INLET, OR JUNCTION
CHANNEL OR CONDUIT DESIG C-5-4
CITY LIMITS
COUNTY (METRO) BOUNDARY
LEVEE

CULVERT
HOLDING POND OR LAKE

1/2 1/4 0 MILES 1
1000 500 0 FEET 4000

NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

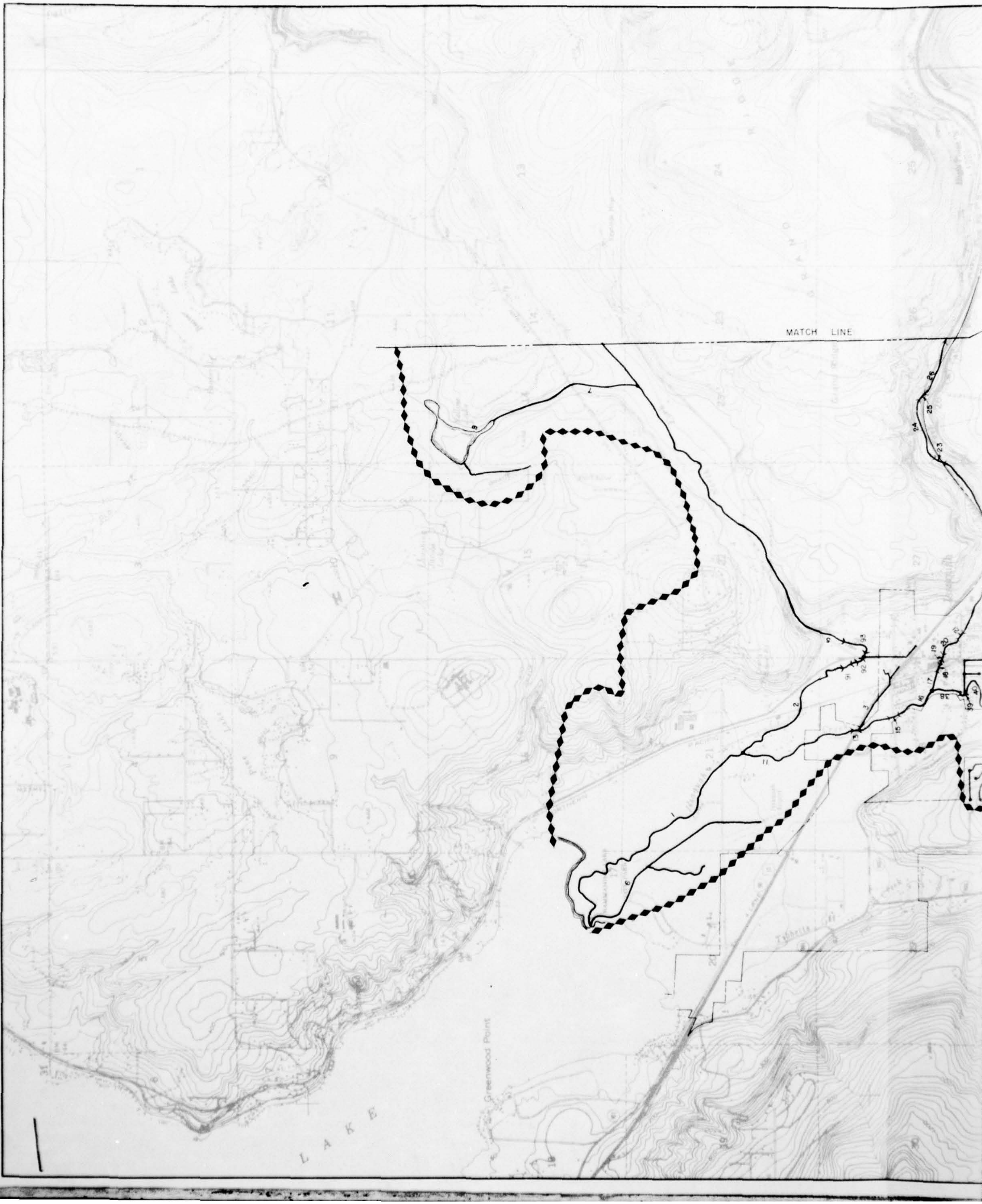
ISSAQUAH CREEK

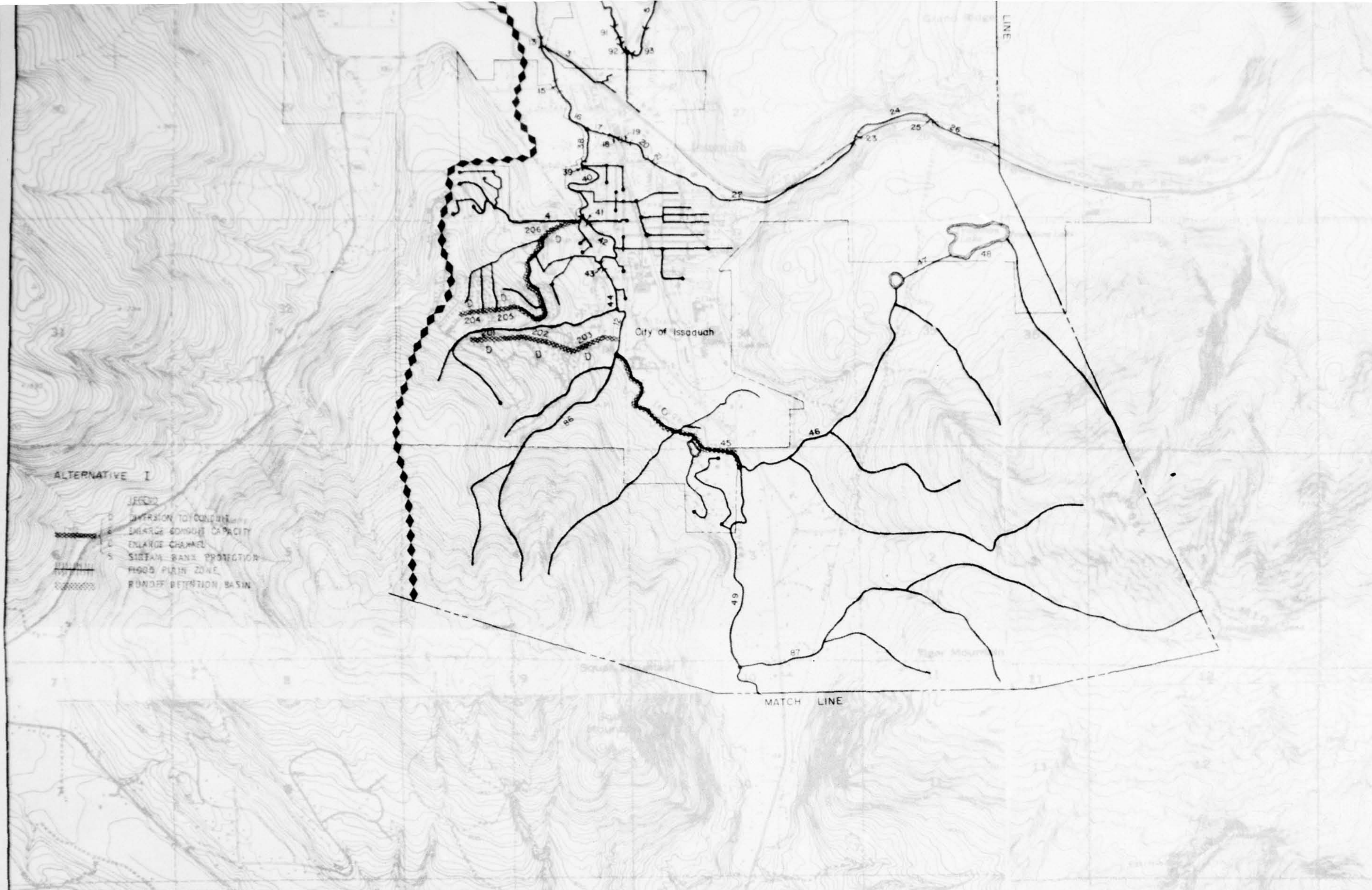
PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

KRAMER, CHIN AND MAYO, INC
WATER RESOURCES ENGINEERS, INC
YODER, TROTTER, ORLOB & ASSOCIATES

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO E-26-1-161 SHEET 4 OF 4


MATCH LINE
Greenwood Point
L A K E



LEGEND

SUB-BASIN BOUNDARY	
EXISTING CHANNEL	
EXISTING CONDUIT	
MANHOLE, INLET, OR JUNCTION	
CHANNEL OR CONDUIT DESIG.	5
CITY LIMITS	
COUNTY (METRO) BOUNDARY	
LEVEE	
CULVERT	
HOLDING POND OR LAKE	

N

1/2 1/4 0 1
MILES
1000 500 0 4000
FEET

NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

ISSAQUAH CREEK

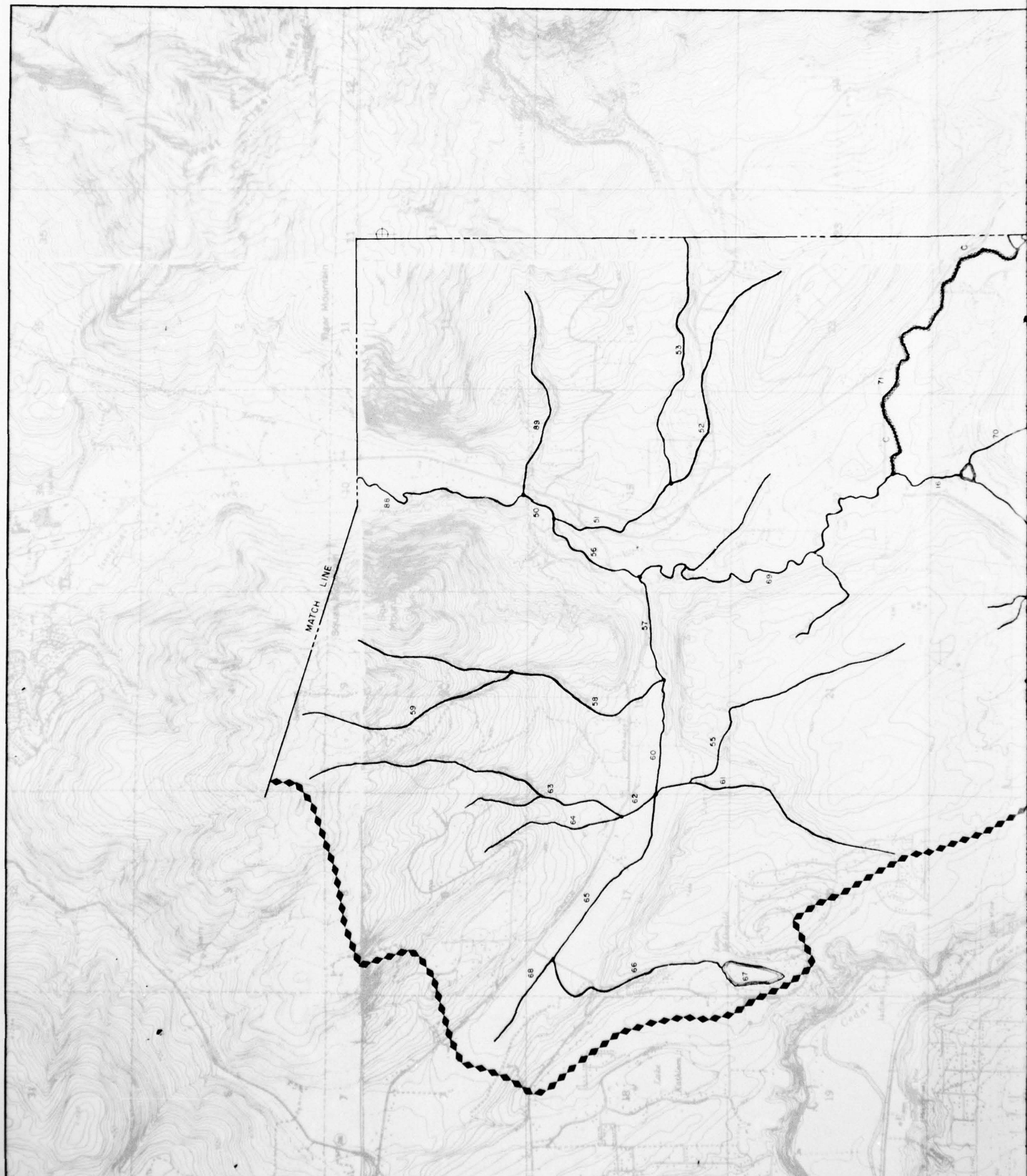
PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

KRAMER, CHIN AND MAYO, INC
WATER RESOURCES ENGINEERS, INC
YODER, TROTTER, ORLOB & ASSOCIATES

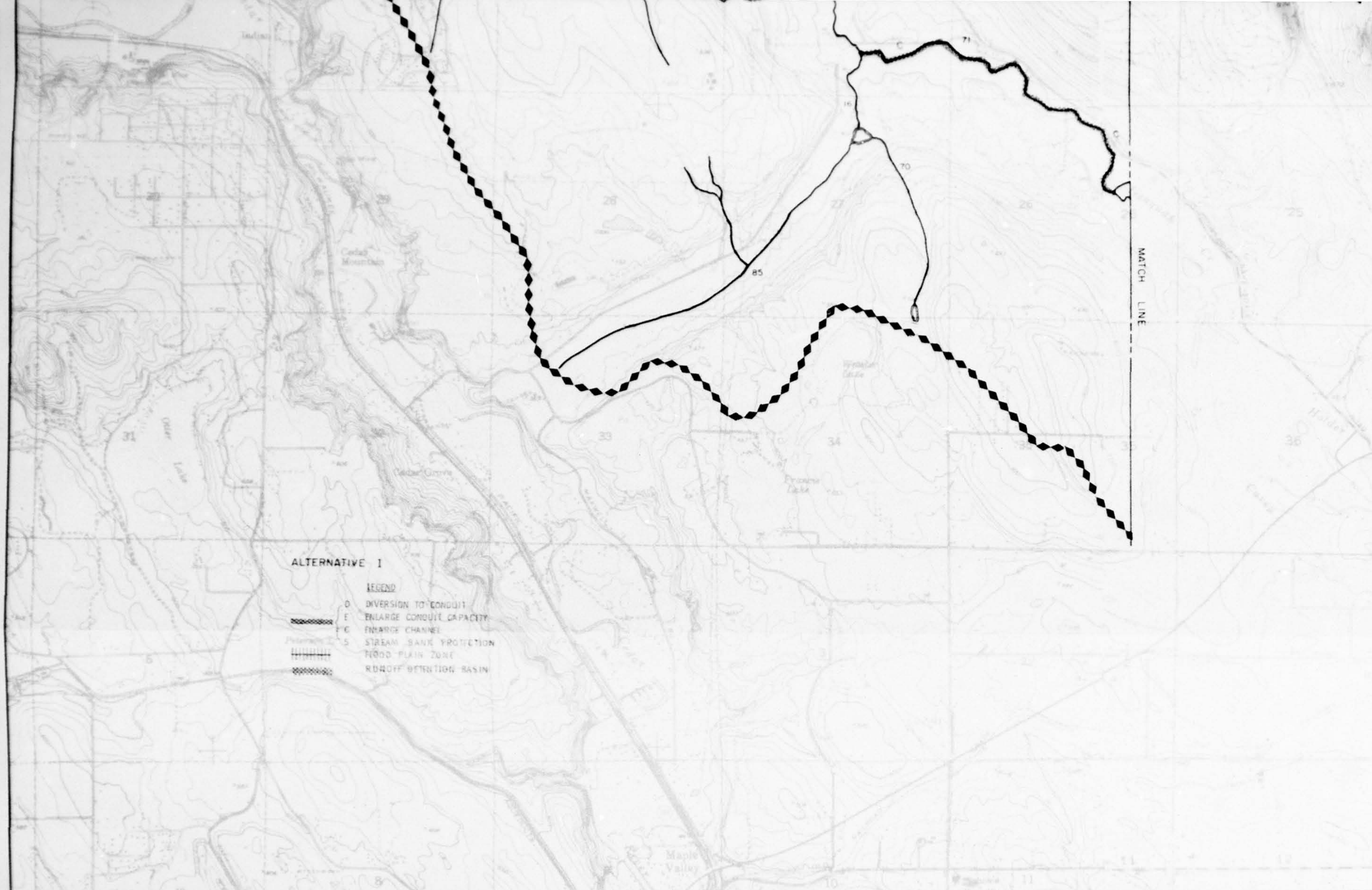
U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO E-26-1-161 SHEET 1b OF 4

2



MATCH LINE
50
51
52
53
55
56
57
58
59
60
61
62
63
64
65
66
67
69
70
71



LEGEND

SUB-BASIN BOUNDARY	
EXISTING CHANNEL	
EXISTING CONDUIT	
MANHOLE, INLET, OR JUNCTION	
CHANNEL OR CONDUIT DESIG.	5
CITY LIMITS	
COUNTY (METRO) BOUNDARY	
LEVEE	
CULVERT	
HOLDING POND OR LAKE	

N

1/2 1/4 0 1
MILES
1000 500 0 4000
FEET

NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

ISSAQUAH CREEK

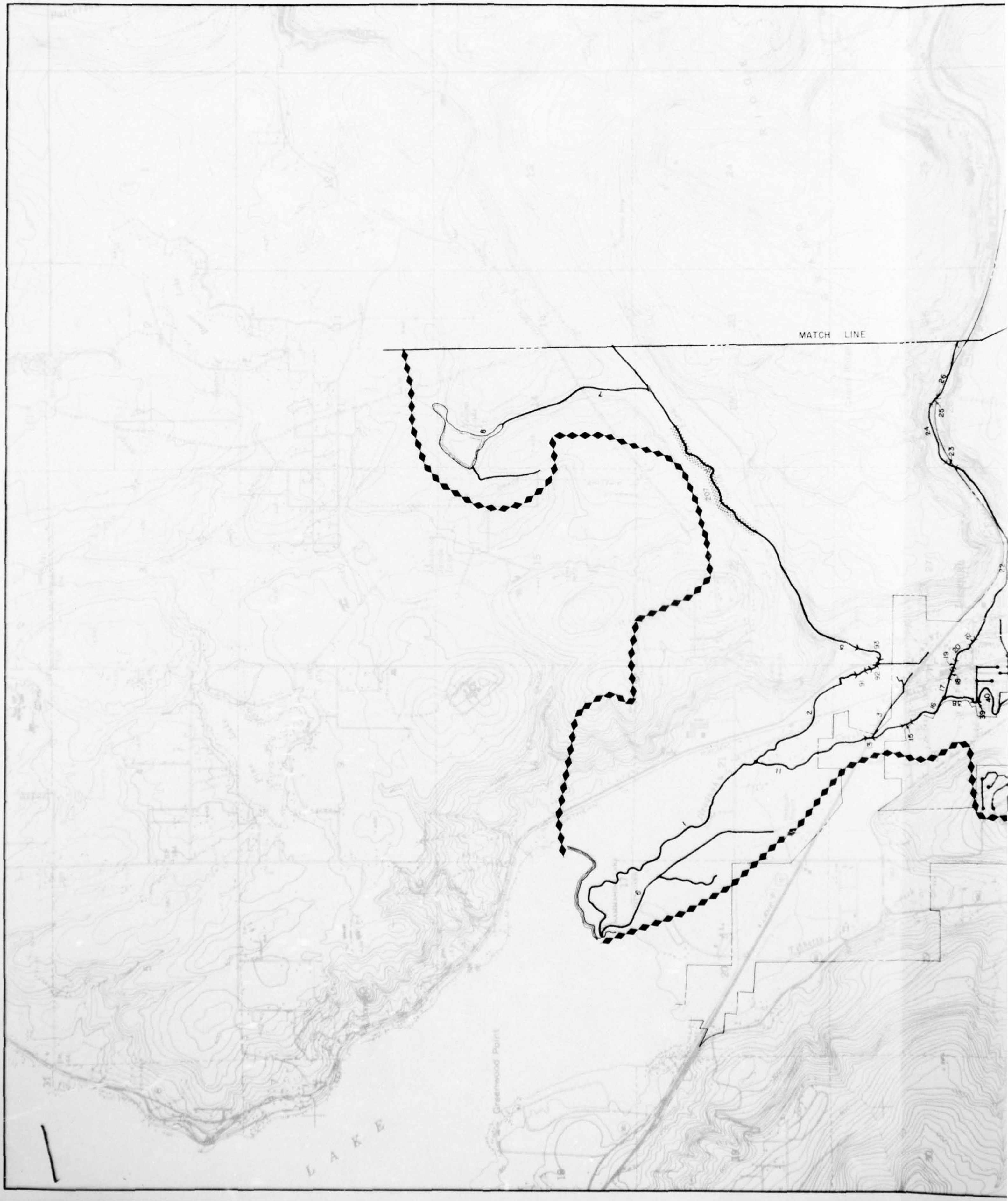
PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

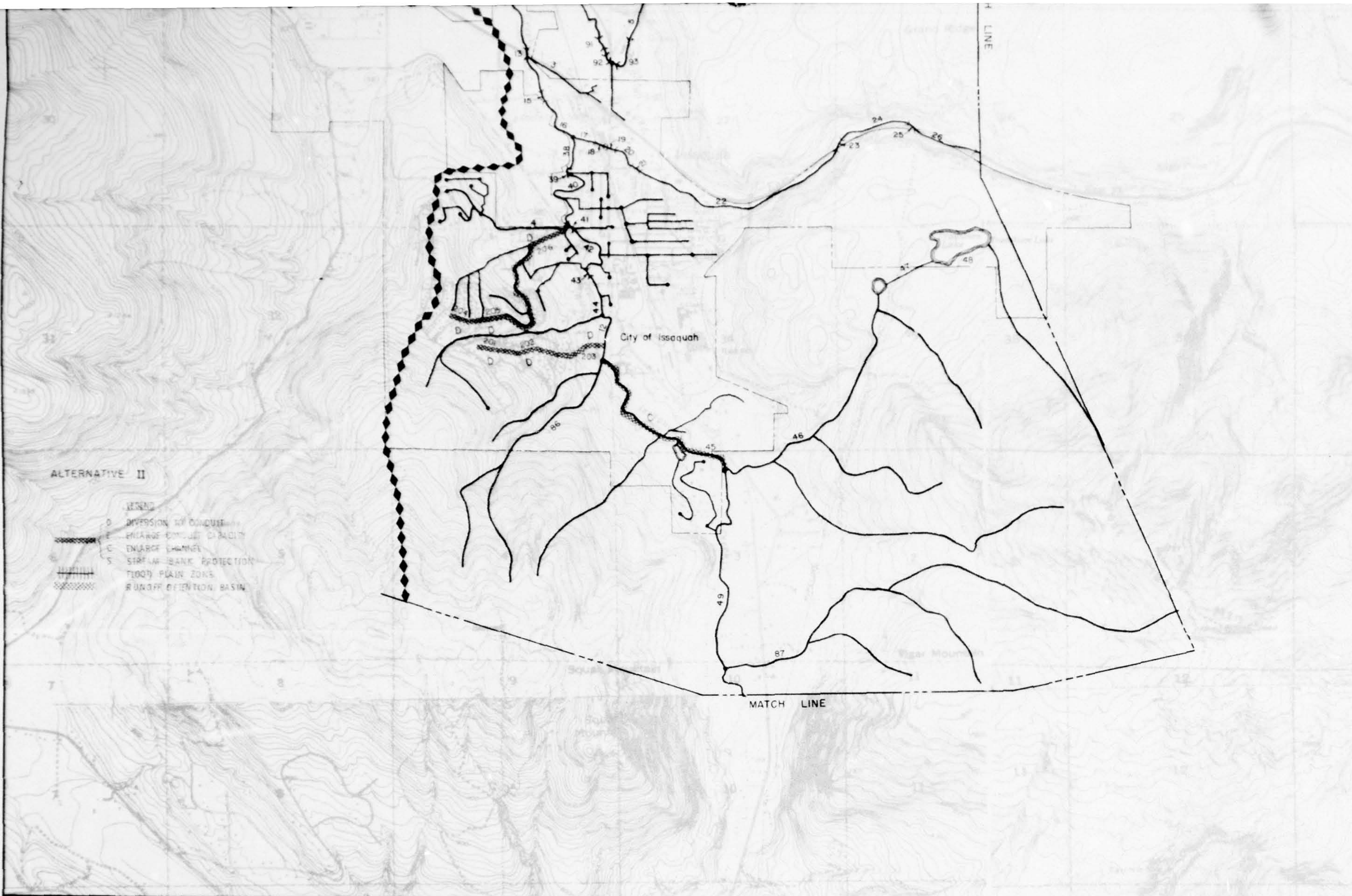
...ER, CHIN AND MAYO, INC.
WATER RESOURCES ENGINEERS, INC.
YODER, TROTTER, ORLOB & ASSOCIATES

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO. E-26-1-161 SHEET 3b OF 4

2


MATCH LINE
Greenwood Point
LAKE



LEGEND

SUB-BASIN BOUNDARY
EXISTING CHANNEL
EXISTING CONDUIT
MANHOLE, INLET, OR JUNCTION
CHANNEL OR CONDUIT DESIG
CITY LIMITS
COUNTY (METRO) BOUNDARY
LEVEE
CULVERT
HOLDING POND OR LAKE

MILES 1/2 1/4 0 1
FEET 1000 500 0 4000

NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

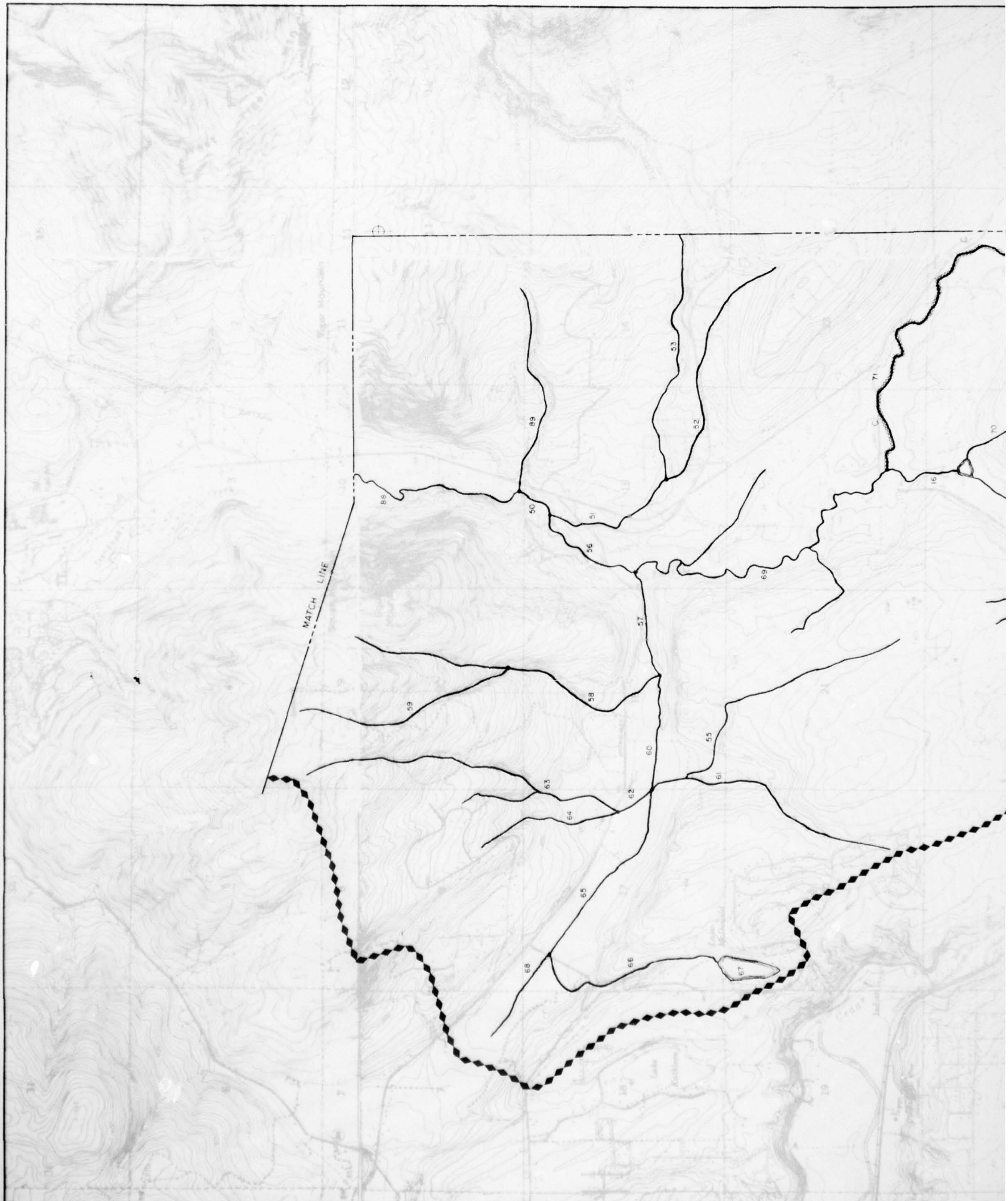
ISSAQUAH CREEK

PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

KRAMER, CHIN AND MAYO, INC
WATER RESOURCES ENGINEERS, INC
YODER, TROTTER, ORLOB & ASSOCIATES

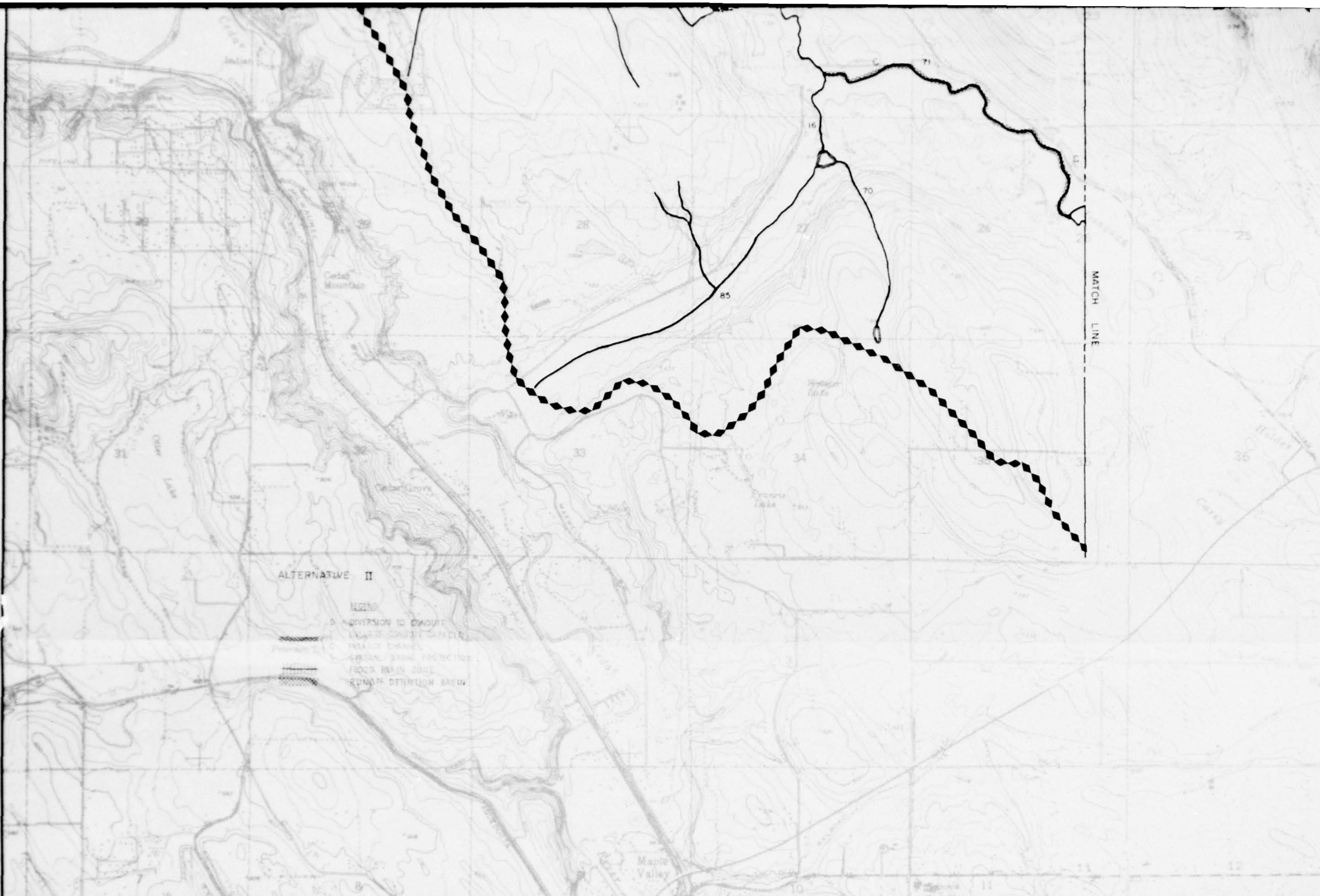
U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO E-26-1-161 SHEET 1c OF 4


MATCH LINE
50
51
52
53
55
56
57
58
59
60
61
62
63
64
65
66
67
69
70
71

AD-A042 166 KCM-WRE/YTO SEATTLE WASH F/G 8/8
ENVIRONMENTAL PLANNING FOR THE METROPOLITAN AREA CEDAR-GREEN RI--ETC(U)
DEC 74 DACW67-73-C-0022
UNCLASSIFIED NL

2 OF 6
AD
A042166



LEGEND

- SUB-BASIN BOUNDARY
- EXISTING CHANNEL
- EXISTING CONDUIT
- MANHOLE, INLET, OR JUNCTION
- CHANNEL OR CONDUIT DESIG. 5
- CITY LIMITS
- COUNTY (METRO) BOUNDARY
- LEVEE
- CULVERT
- HOLDING POND OR LAKE

NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

ISSAQUAH CREEK

PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

KRAMER, CHIN AND MAYO, INC
WATER RESOURCES ENGINEERS, INC
YODER, TROTTER, ORLOB & ASSOCIATES

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO E-26-1-161 SHEET 3 OF 4

REGIONAL SUB-BASIN C-4

LAKE SAMMAMISH

GENERAL DESCRIPTION

This sub-basin encompasses the total Lake Sammamish drainage area except the Issaquah Creek Sub-Basin. In all, there are 13 creeks discharging into the lake, all but two are unnamed, and drain relatively small areas. Tibbetts Creek, that drains the western side of Squak Mountain and the eastern side of Cougar Mountain, is the largest stream in this sub-basin. It drains four square miles and discharges to Lake Sammamish at the southern end west of Issaquah Creek.

Land use in this sub-basin is very diversified. It ranges from almost totally undeveloped land in the south to dense residential development on the west. East of the lake, the land rises rapidly to a plateau with elevations that range from 350 feet to 500 feet. This area is lightly developed at present, the greatest concentration of homes are in the vicinity of Pine Lake and Beaver Lake. Industrial and commercial areas are concentrated at Eastgate along the I-90 corridor, and at the foot of Squak Mountain along the banks of Tibbetts Creek.

Future residential development is expected on both sides of Lake Sammamish. The area of greatest potential is the Pine Lake plateau that will be in great demand once the I-90 corridor into Seattle is completed and east side travel is simplified. It also is likely that commercial and industrial growth will expand both in the Eastgate area and in the Tibbetts Creek area. The latter is presently developing rapidly and will eventually incorporate the entire flood plain of Issaquah Creek and Tibbetts Creek.

PERCENT OF SUB-BASIN AREA IN SPECIFIED LAND USE

Land Use	Existing (1970-72)	P.S.G.C. Land Use Projection Comprehensive	Corridor
Single Family	13	25	25
Multiple Family	5	7	7
Commercial/Services	2	4	4
Govt. and Educ.	<1	1	1
Industrial	2	4	4
Parks/Dedicated Open Space	10	5	5
Agriculture	10	6	6

Land Use	Existing (1970-72)	P.S.G.C. Land Use Projection Comprehensive	Corridor
Airports, Railyards, Freeways, Highways	< 1	1	1
Unused Land	35	25	25
Water	22	22	22
Total	100	100	100
Total Impervious Area	15	25	25

Jurisdiction in this sub-basin is divided between three incorporated cities and King County. The county has formed West and Southwest Lake Sammamish Flood Control Zone Districts that encompass most of the west side drainage to the lake. In the [illegible] end of the sub-basin, part of Tibbetts Creek flows through the City of Issaquah on the west side of Lake Sammamish, the south portion of the sub-basin is in the City of Bellevue, except for a small area in Eastgate and along Phantom Lake that is within the boundaries of the FCZD, and the north end is in the City of Redmond. The remainder of the sub-basin, (75%), including the entire east side, is within the jurisdiction of King County, including a small piece of land on the southern end that encompasses Lake Sammamish State Park.

The area west of Lake Sammamish is within the service area of Metro. The City of Issaquah sewer system will discharge to Metro by contract as eventually may the Pine Lake area.

NATURE OF EXISTING DRAINAGE SYSTEM

Although this sub-basin is developed to a substantial degree, especially on the west side of Lake Sammamish, drainage generally flows through open ravines to the lake. Creeks in these ravines, in many cases, have been badly eroded because of heavy runoff generated upstream, but only in few cases have conduits replaced natural drainages. In new developments, storm sewers have been installed, but they still discharge to ravines and often cause increased erosion. The streams and rivulets tributary to Tibbetts Creek largely are in their natural state. However, in the lower reaches adjacent to the developing commercial district, Tibbetts Creek has been channelized.

East of Lake Sammamish, the streams have their headwaters in bogs and lakes that, in most cases, have not as yet been seriously encroached upon by development. In a number of instances, development has occurred directly adjacent to creeks and the concurrent increase in impervious area has generated heavy storm-water runoff that has caused localized erosion.

DRAINAGE PROBLEMS

Most of the problems in this sub-basin are the result of uncontrolled upland development. As hard, impervious surfaces cover natural terrain, the ability of the ground and vegetation to absorb and slow the rate at which rain runs off the land is decreased and the resultant excessive flows cause stream erosion and subsequent lakeshore sedimentation. This increased flow also tends to carry more than a normal amount of debris, and in a number of cases, problems caused by debris deposition have been reported.

A sub-basin problem that has yet to be identified is the degree of pollution caused by storm-water runoff. About four miles of the I-90 corridor drains to Lake Sammamish, as does approximately 17 miles of perimeter road and an undetermined length of residential streets. Also, increased residential development brings drainage from additional arterials, access roads, and urban installation. Runoff from these developments carries dirt, oil and other pollutants to the lake. To date, no specific adverse effects have been identified, but in the future this may become a significant consideration.

The results of hydrologic analyses of the year 2000 Comprehensive and Corridor land-use plans indicate no significant difference between runoff generated by the two plans. Therefore, the drainage alternatives presented herein are applicable to both plans. The existing drainage problems will become more severe because of increases in impervious area and faster runoff. The total impervious area in this sub-basin with either land-use projection will increase from the existing 15% level to approximately 25% as shown in the table of projected land uses.

BASIC ISSUES AND STATUS OF DRAINAGE PLANNING

Existing planning for this sub-basin includes a 1971 study by the Corps of Engineers, and Comprehensive Plans for the West and Southwest Lake Sammamish Flood Control Zone District developed by King County in 1965. The Issaquah Planning Department also has completed a Comprehensive Land Use Plan for a portion of the sub-basin that is presently being considered for adoption.

The Corps study area included the lower 2.3 miles of Tibbetts Creek. The report established boundaries of a portion of the flood plain that would have a one percent chance of being exceeded each year. The report recommended that development be regulated within a designated flood plain.

The Southwest Lake Sammamish Flood Control Zone District encompasses the Phantom Lake and Eastgate areas, and the Comprehensive Plan for that district give descriptions of storm-sewer requirements to meet present and future needs.

Other general planning efforts conducted within this sub-basin include the 1964 King County Comprehensive Plan for Flood Control prepared by the King County Department of Public Works, Division of Hydraulics, and an Urban Trails Plan developed in 1971 by the King County Department of Planning.

Staff members from King County Public Works Department, Hydraulics Division, and the Redmond Public Works Department have reviewed the initial alternative plans for drainage developed by this RIBCO Study for Lake Sammamish Sub-Basin.

ALTERNATIVE PLANS FOR PROPOSED DRAINAGE CONTROL

The existing drainage system of the Lake Sammamish Sub-Basin, as described by local agencies, was evaluated by computer simulation that applied the region's ten-year storm to the year 2000 land use. Drainage problems thus identified were analyzed and possible solutions were provided in development of alternative plans for drainage control as described below.

ALTERNATIVE PLAN I

General Concept

Alternative Plan I provides conventional treatment of the drainage problems in this sub-basin including enlarged channels, enlarged conduits and streambank protection in areas where erosion is or could become a problem.

Major Features

On the west side of the lake, the primary facilities recommended are storm sewers to replace existing undersized lines. Diversion-type piping systems would serve downstream from Phantom Lake as well as from the Eastgate Shopping area. The plans for both areas are similar to those developed by the Southwest Lake Sammamish Flood Control Zone District except it is recommended here that construction be limited to public right-of-ways instead of stream beds wherever possible. This would serve to allow for proper drainage and preservation of the creeks themselves.

On the east side of the lake, the primary problem is erosion of the streambanks on the steep hillsides. This alternative proposes streambank protection and construction of drop structures at intervals along the stream to slow velocities and reduce scouring. Some channel widening also is proposed downstream from Beaver Lake.

In the Tibbetts Creek area the proposed facilities involve primarily channel widening and culvert construction to allow greater flows to pass directly to Lake Sammamish.

Cost

The cost for Alternative Plan I is estimated to be $2,200,000.

ALTERNATIVE PLAN II

General Concept

Alternative Plan II considers making use of the storage and controlled release concept in urban drainage wherever possible. This is particularly applicable to the areas on the east side of Lake Sammamish where land is still relatively undeveloped and the topography is such that it would be relatively simple to berm and use lake storage.

This alternative also considers streambank protection, channel widening, and storm-sewer construction, particularly on the west side of the lake where other alternatives are not available.

Major Features

The major features in Alternative Plan II include six holding ponds east of Lake Sammamish and one holding pond on the west. Four of the seven selected sites are well known lakes including Phantom Lake, Pine Lake, Beaver Lake and Laughing Jacobs Lake. In each instance, the lakes would be controlled by outlet structures so that the lake level would not adversely affect residential use of the surrounding land.

Storm sewers are proposed for the residential areas in the northwest portion of the sub-basin, and in the southwest, the natural channels, protected with rip-rap would be used instead of conventional storm sewers.

In Tibbetts Creek on the south end of Lake Sammamish, the only reasonable alternative solution to that previously proposed would be to do no work at all and allow the flat lands to flood periodically. However, the City of Issaquah, as previously noted, has a Flood Hazard Zone Ordinance that will soon be amended to include Tibbetts Creek. If properly implemented, this ordinance could serve to control development in this flood-prone area. Indications from preliminary observations are that a portion of the possible floodway is already built upon and further construction is in progress. If the Flood Hazard Zone Ordinance is to be effective, the impact of this development should be assessed as soon as possible and further development in the floodway should be halted. Once the floodway is established, existing buildings would be eligible for flood insurance through the National Flood Insurance Program.

Because of recent industrial development and the fill material brought in to serve as foundations for the new buildings, the actual floodway area is difficult to determine. Construction has taken place on the east side of Tibbetts Creek with a possible consequence being that the west side would become more vulnerable to flood waters. If that is indeed the case, it may be most practical to allow present development to

continue on the east side of the creek and dedicate the west side as a shallow storage pond in which controlled flooding would be allowed. This land could serve as open space for recreational purposes during dry periods. Before a decision can be made as to the appropriate step, a determination should be made relative to the effect of the industrial property on the creek and the boundaries of the flood plain. For purposes of this report, it will be assumed that channelization of the creek as described in Alternative Plan I will be implemented. However, since flood-plain zoning or the use of a controlled floodway would cost less than channelization, serious consideration should be given to zoning and control prior to further construction of industrial building, and after a determination is made as to the location of flooding limits.

Cost

The cost for Alternative Plan II is estimated to be $1,700,000.

PEAK FLOW COMPARISONS

The following table indicates 10-year peak flows with existing facilities and with alternative drainage-management solutions for the year 2000.

COMPARISON OF 10-YEAR PEAK FLOWS
(Cubic Feet per Second)

Location	Existing Facilities	Alternative Plan I	Alternative Plan II
Mouth of Tibbetts Creek	225	875	875
Mouth of Channel Draining Eastgate	150	480	475
Mouth of Channel Draining Phantom Lake	100	250	70
Mouth of Channel Draining Beaver Lake	350	850	550

ENVIRONMENTAL ASSESSMENT OF ALTERNATIVE PLANS

Field inspections were made to judge the applicability of the suggested alternative plans for this sub-basin. This process was followed throughout the RIBCO Study for development of alternative plans for the various regional sub-basins. The inspections were based upon the alternative evaluation procedure which identified 34 unique criteria grouped in general categories as follows: 1) Effectiveness, 2) Human Values, 3) Environmental Factors, 4) Implementation, and 5) Resource Re-

quirements. The various structural solutions were checked against the appropriate criteria and the various non-structural solutions were reviewed for their relationship to existing and probable future developments. The criteria rating total for Alternative Plan I, which employs channelization, streambank protection, diversion and enlarged conduit, was a minus 25 on a scale ranging from positive 108 to negative 108. The total evaluation-rating for Alternative Plan II, which employs storage, channelization, streambank protection, and enlarged conduit, was a plus 22.

Both alternatives were judged to be effective for controlling storm runoff with Alternative Plan II receiving a higher rating, primarily because of the potential for erosion and sedimentation control and system flexibility. Both alternatives also promoted human values and again Alternative Plan II received a higher rating. The use of major wetland storage areas should enhance the urban quality of this sub-basin. The two alternative plans received divergent scores for environmental factors with Alternative Plan II receiving a positive rating because of the potential for water quality control and the assurance of low-flow conditions. Alternative Plan I was believed to be detrimental to wildlife, aquatic life and vegetation. Both alternative plans are judged to be relatively difficult to implement because of the numerous jurisdictions involved. Alternative Plan II would suffer the effects of inaction as it relies upon the utilization of existing wetlands for storage areas. If these areas are not secured prior to development, Alternative Plan II would have questionable implementation potential. Alternative Plan II was rated superior in resource requirements although it involves a trade-off between a relatively high capital cost and the provision for multi-purpose use of land. Alternative Plan I requires an extensive commitment of energy resources, land and capital.

The one critical element in Alternative Plan II is the proposal to use natural wetland storage areas. This treatment, if it is to be part of the chosen alternative, should be implemented as an early organized effort by the involved agencies. The loss of these wetlands would then force the use of more structural treatment than Alternative Plan II can accommodate. This issue should be brought to the attention of all citizens and their local agencies.

CONCLUSIONS

Alternative Plan II is clearly superior to Alternative Plan I because of the potential for use of major existing storage areas. It does require immediate action, however to protect and preserve these natural amenities. As pointed out above, this action would require coordination of the involved agencies in the Lake Sammamish Sub-Basin.

King County, the West Sammamish Flood Control Zone District, and the cities of Bellevue, Redmond and Issaquah should establish an effective agreement for a master drainage plan, that incoporates the provisions of Alternative Plan II. All agencies should then move to acquire rights to

the necessary holding ponds within their own jurisdiction.

The basic issue appears to be which local agency or agencies will have jurisdiction and responsibility for control of urban drainage and related flood damage problems. King County should have primary reponsibility for control of drainage and flood damage and the involved cities should have control within their respective boundaries.

RUNOFF QUALITY SUMMARY
LAKE SAMMAMISH

BASED UPON A 10-YEAR STORM PRECEDED BY 15 DAYS WITH LITTLE OR NO RAINFALL#

LOCATION	ALTERNATIVE PLAN	PEAK FLOW (cfs)	CONCENTRATION AT PEAK FLOW*				
			BOD	TOTAL COLIFORM	NH_3	$NO_2 + NO_3$	PO_4
Tibbetts Creek	I	875	16	1.0×10^5	.4	1.1	.3
	II	875	16	1.0×10^5	.4	1.1	.3
Channel draining Phantom Lake	I	250	7	1.3×10^5	.1	.5	.2
	II	70	4	$.7 \times 10^5$	.1	.4	1.5
Channel draining Beaver Lake	I	850	8	1.5×10^5	1.1	.5	.2
	II	550	6	1.2×10^5	.1	.4	.2

Less than a total of 0.5 inches of rainfall in any one day.
* Concentrations in mg/liter except total coliform which is in MPN/100 ml.

EVALUATION MATRIX

LAKE SAMMAMISH

ALTER- NATIVES	SUB TOTAL	EFFECTIVENESS: Use of existing facilities	System reliability	System maintainability	System flexibility	Flood damage reduction	Consequences of overcharge	Erosion and sedimentation control	Cost/benefits ranking	SUB TOTAL	HUMAN VALUES: Urban quality (aesthetics)	Effect on land use	Displacement of people	Educational value	Community cohesion	Multiple use potential	Public health and safety	SUB TOTAL	ENVIRONMENTAL FACTORS: High flow conditions	Alteration of natural system	Effects on groundwater	Low flow conditions	Water quality	Construction disruption	Effects on wildlife	Effects on aquatic life	Effects on vegetation	SUB TOTAL	IMPLEMENTATION: Legislative requirements	Jurisdictional	Land acquisition	Public acceptance	Financing	Effects of no action	SUB TOTAL	RESOURCE REQUIREMENTS: Energy	Materials	Land	Capital	RATING TOTAL
		CRITERIA WEIGHT 1	4	3	2	4	4	4	2		CRITERIA WEIGHT 4	2	2	1	3	3	4		CRITERIA WEIGHT 4	4	4	4	4	2	4	4	4		CRITERIA WEIGHT 4	4	2	4	4	3		CRITERIA WEIGHT 3	3	2	2	
I	+5									+1								-22										-1							-8					-25
II	+14									+9								+6										-7							0					+22

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative I Sub-Basin Lake Sammamish

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
73	Pipe	18"	2,500'			Parallel Pipe	36"	$165,000
70	Pipe	18"	1,200'			Parallel Pipe	42"	$95,000
64	Pipe	18"	1,000'			Parallel Pipe	18"	$30,000
61	Pipe	18"	2,600'			Parallel Pipe	18"	$78,000
30	Channel	6'	2,500'	1:1	4'	Parallel Pipe	54"	$265,000
26	Pipe	Three-48"	300'			Parallel Culvert	15' x 4'	$154,000
90	Culvert	Two-73"x45" CMP arch Two-58"x36" CMP arch	50'			Replacement Culvert	15' x 4'	$26,000
91	Box Culvert	4' x 4'	60'	1:1		Parallel Culvert	54"	$15,000
41	Channel	4'	3,500'	1:1	3'	Diversion Pipe	36"	$231,000
40	Channel	4'	3,000'	1:1	3'	Diversion Pipe	48"	$279,000
39	Channel	5'	1,800'	1:1	4'	Diversion Pipe	54"	$191,000
54	Channel	3'	1,400'	1:1	3'	Diversion Pipe	42"	$111,000
53	Channel	3'	1,500'	1:1	3'	Diversion Pipe	42"	$119,000
27	Channel	6'	3,000'	1:1	4'	Channel	22' width 4' depth 2:1 side slopes	$62,000
92	Channel	6'	4,000'	1:1	4'	Channel	22' width 4' depth 2:1 side slopes	$83,000
35	Channel	7'	1,000'	1:1	4'	Channel	22' width 4' depth 2:1 side slopes	$22,000
34	Channel	8'	700'	1:1	4'	Channel	32' width 4' depth 2:1 side slopes	$20,000

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative I Sub-Basin Lake Sammamish

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
23	Channel	7'	2,000'	1:1	5'	Channel	30' width 5' depth 2:1 side slopes	$70,000
12	Channel	7'	1,500'	1:1	4'	Channel	16' width 4' depth 2:1 side slopes	$22,000
14	Channel	7'	1,300'	1:1	4'	Channel	13' width 4' depth 2:1 side slopes	$16,000
16	Channel	7'	1,500'	1:1	4'	Channel	8' width 4' depth 2:1 side slopes	$11,000
18	Channel	7'	1,500'	1:1	4'	Channel	8' width 4' depth 2:1 side slopes	$10,000
111	Channel	4'	1,000'	1:1	3'	Channel	Streambank protection and drop structures	$14,000
110	Channel	4'	1,000'	1:1	3'	Channel	Streambank protection and drop structures	$14,000
2	Channel	10'	1,500'	1:1	6'	Channel	Streambank protection and drop structures	$28,000
7	Channel	7'	1,200'	1:1	4'	Channel	Streambank protection and drop structures	$27,000
9	Channel	7'	3,000'	1:1	4'	Channel	Streambank protection and drop structures	$35,000
22	Channel	8'	8,500'	1:1	5'	Channel	Streambank protection 2000' only and drop structures	$30,000

Total Estimated Capital Cost: $2,223,000

Round To: $2,200,000

The Estimated Capital Cost for each element includes Contractor profit, engineering, legal and contingencies. In addition, land purchase and severance costs are included where land is required. All costs are based upon June 1973 prices.

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative II Sub-Basin Lake Sammamish

	EXISTING FACILITIES					PROPOSED FACILITIES		
ELEMENT NUMBER	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
73	Pipe	18"	2,500'			Parallel Pipe	36" 36"	$165,000
70	Pipe	18"	1,200'			Parallel Pipe	42" 42"	$95,000
64	Pipe	18"	1,000'			Parallel Pipe	18" 18"	$30,000
61	Pipe	18"	2,600'			Parallel Pipe	18" 18"	$78,000
91	Culvert	4'	60'	0	4'	Parallel Culvert	54" 54'	$15,000
26	Pipe	Three-48"	300'			Parallel Culvert	15' x 4'	$154,000
90	Culvert	Two-73" x 45" CMP arch Two-58" x 36" CMP arch	50'			Replacement Culvert	15' x 4'	$26,000
111	Channel	4'	1,000'	1:1	3'	Channel	Streambank protection	$10,000
110	Channel	4'	1,000'	1:1	3'	Channel	Streambank protection	$10,000
41	Channel	4'	3,500'	1:1	3'	Channel	Streambank protection	$26,000
40	Channel	4'	3,000'	1:1	3'	Channel	Streambank protection	$22,000
39	Channel	5'	1,800'	1:1	4'	Channel	Streambank protection	$18,000
30	Channel	6'	2,500'	1:1	4'	Channel	Streambank protection	$25,000
27	Channel	6'	3,000'	1:1	4'	Channel	22' width 4' depth 2:1 side slopes	$62,000
92	Channel	6'	4,000'	1:1	4'	Channel	22' width 4' depth 2:1 side slopes	$83,000
35	Channel	7'	1,000'	1:1	4'	Channel	22' width 4' depth 2:1 side slopes	$22,000
34	Channel	8'	700'	1:1	4'	Channel	32' width 4' depth 2:1 side slopes	$20,000

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

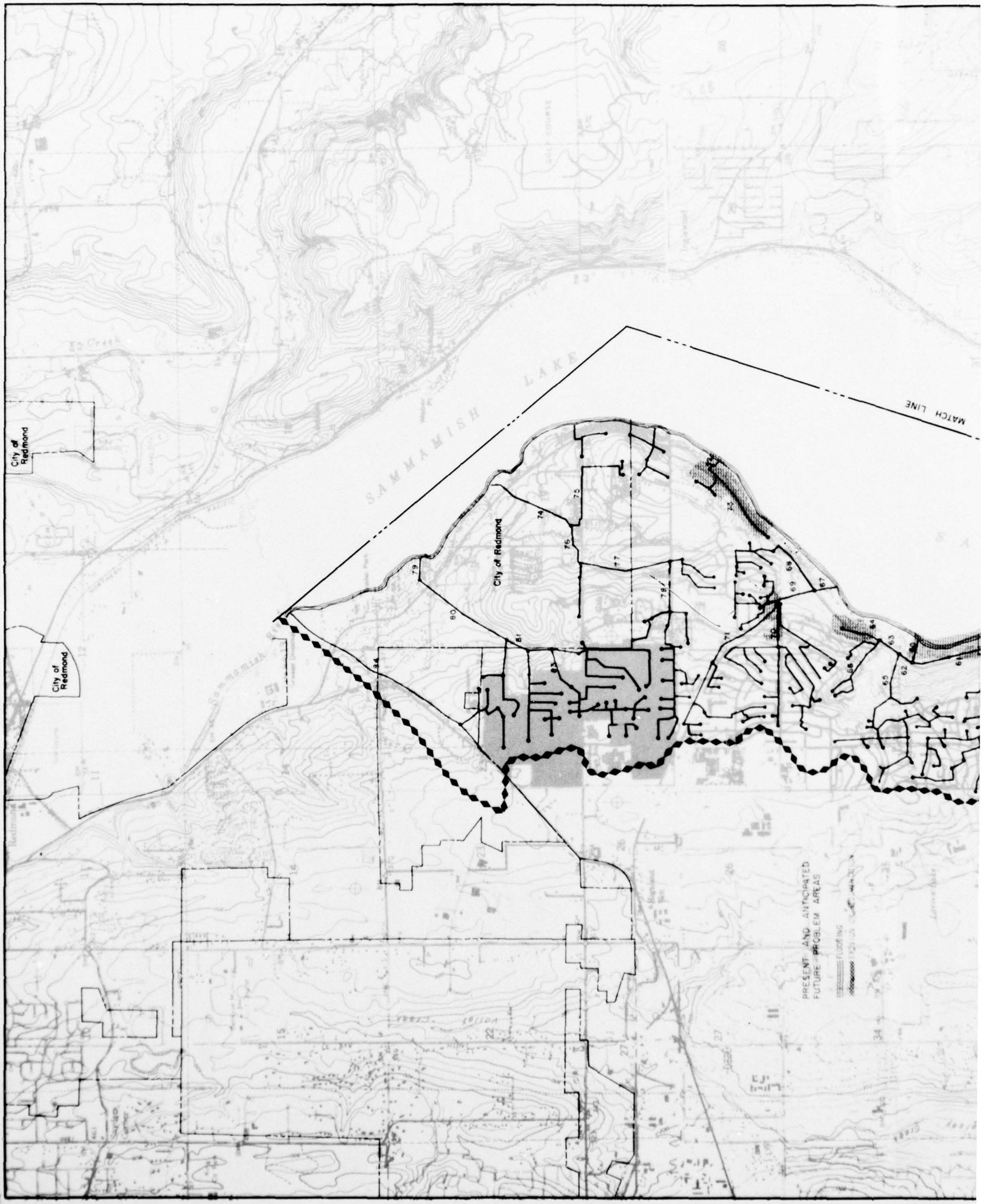
Alternative II Sub-Basin Lake Sammamish

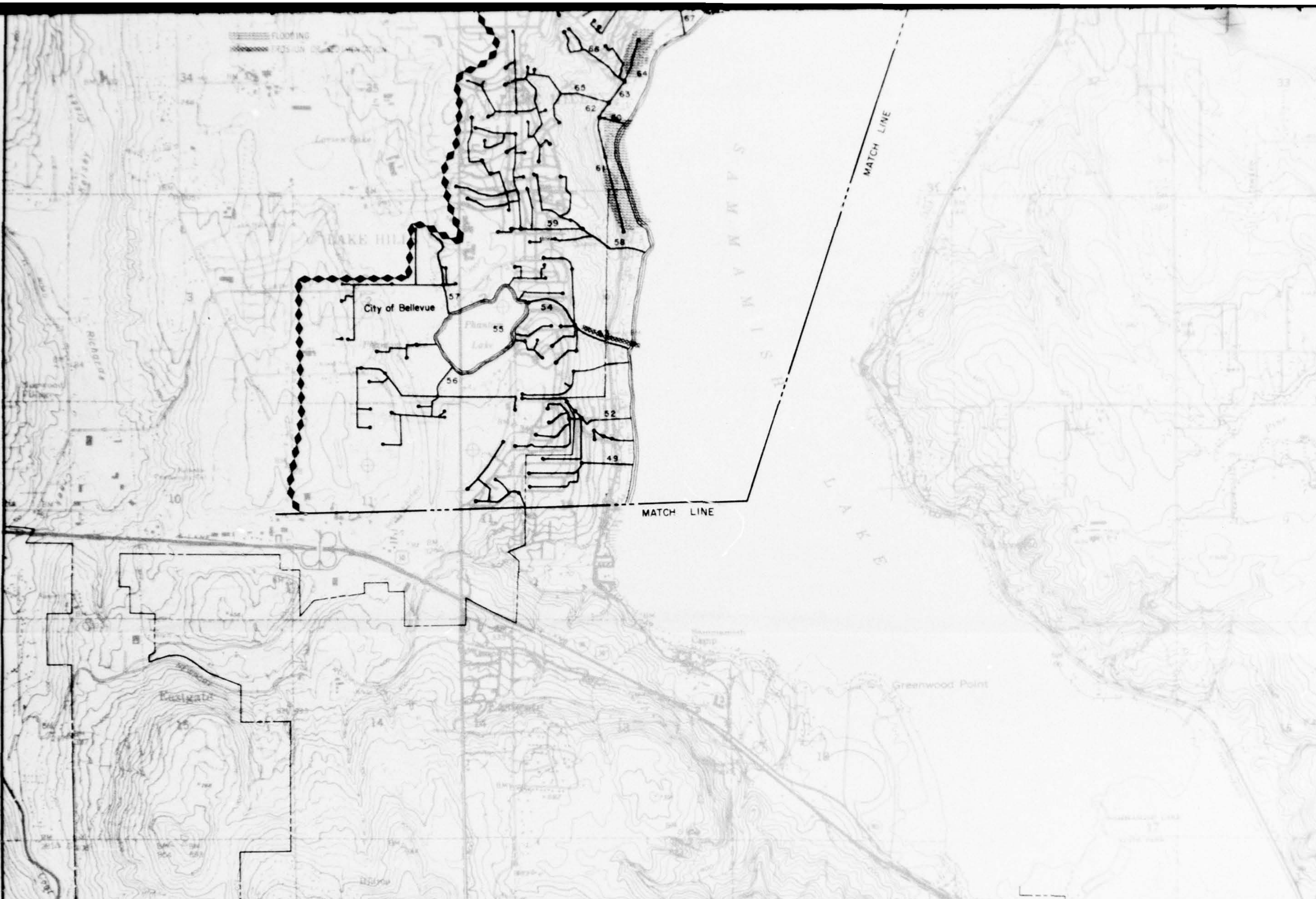
ELEMENT NUMBER	EXISTING FACILITIES: TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	PROPOSED FACILITIES: TYPE		ESTIMATED CAPITAL COST
23	Channel	7'	2,000'	1:1	5'	Channel	30' width 5' depth 2:1 side slopes	$70,000
97	None	(Beaver Lake)				Holding Pond	25 AF	$78,000
96	None					Holding Pond	51 AF	$58,000
95	None	(Laughing Jacobs Lake)				Holding Pond	25 AF	$60,000
99	None					Holding Pond	65 AF	$94,000
94	None					Holding Pond	31 AF	$61,000
93	None	(Pine Lake)				Holding Pond	27 AF	$66,000
98	None	(Phantom Lake)				Holding Pond	25 AF	$75,000
22	Channel	8'	8,500'	1:1	5'	Channel	Streambank protection	$305,000

The Estimated Capital Cost for each element includes Contractor profit, engineering, legal and contingencies. In addition, land purchase and severance costs are included where land is required. All costs are based upon June 1973 prices.

Total Estimated Capital Cost: $1,728,000

Round To: $1,700,000


City of Redmond
City of Redmond
City of Redmond
SAMMAMISH LAKE
MATCH LINE
PRESENT AND ANTICIPATED
FUTURE PROBLEM AREAS



LEGEND

SUB-BASIN BOUNDARY
EXISTING CHANNEL
EXISTING CONDUIT
MANHOLE, INLET, OR JUNCTION
CHANNEL OR CONDUIT DESIG. 5
CITY LIMITS
COUNTY (METRO) BOUNDARY
LEVEE
CULVERT
HOLDING POND OR LAKE

N

1/2 1/4 0 1
MILES
1000 500 0 4000
FEET

NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

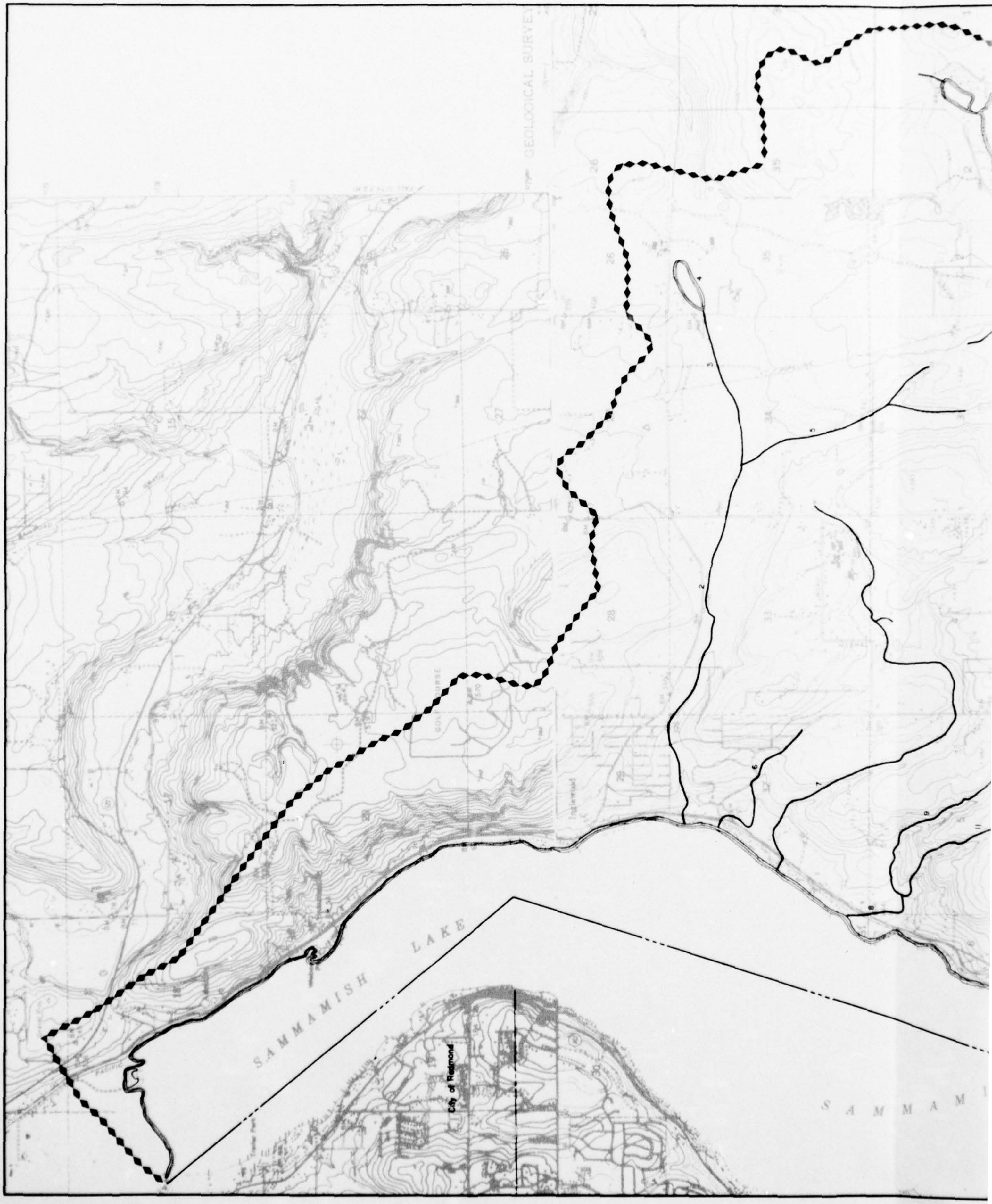
LAKE SAMMAMISH

PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

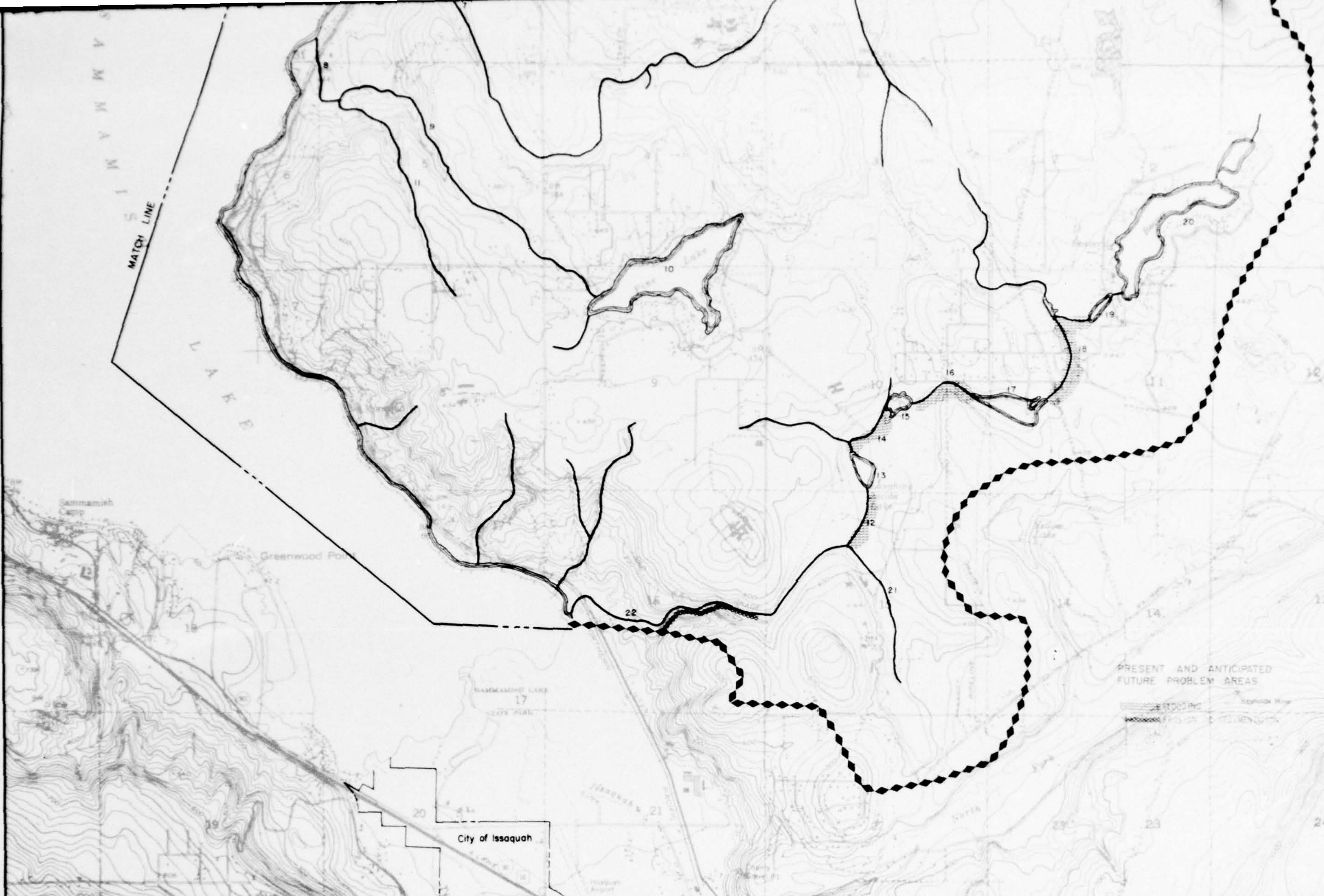
KRAMER, CHIN AND MAYO, INC
WATER RESOURCES ENGINEERS, INC
YODER, TROTTER, ORLOB & ASSOCIATES

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO E-26-1-161 SHEET 1D OF 3



1



LEGEND

- SUB-BASIN BOUNDARY
- EXISTING CHANNEL
- EXISTING CONDUIT
- MANHOLE, INLET, OR JUNCTION
- CHANNEL OR CONDUIT DESIG. 5
- CITY LIMITS
- COUNTY (METRO) BOUNDARY
- LEVEE
- CULVERT
- HOLDING POND OR LAKE

N

1/2 1/4 0 1 MILES

1000 500 0 4000 FEET

NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

LAKE SAMMAMISH

PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

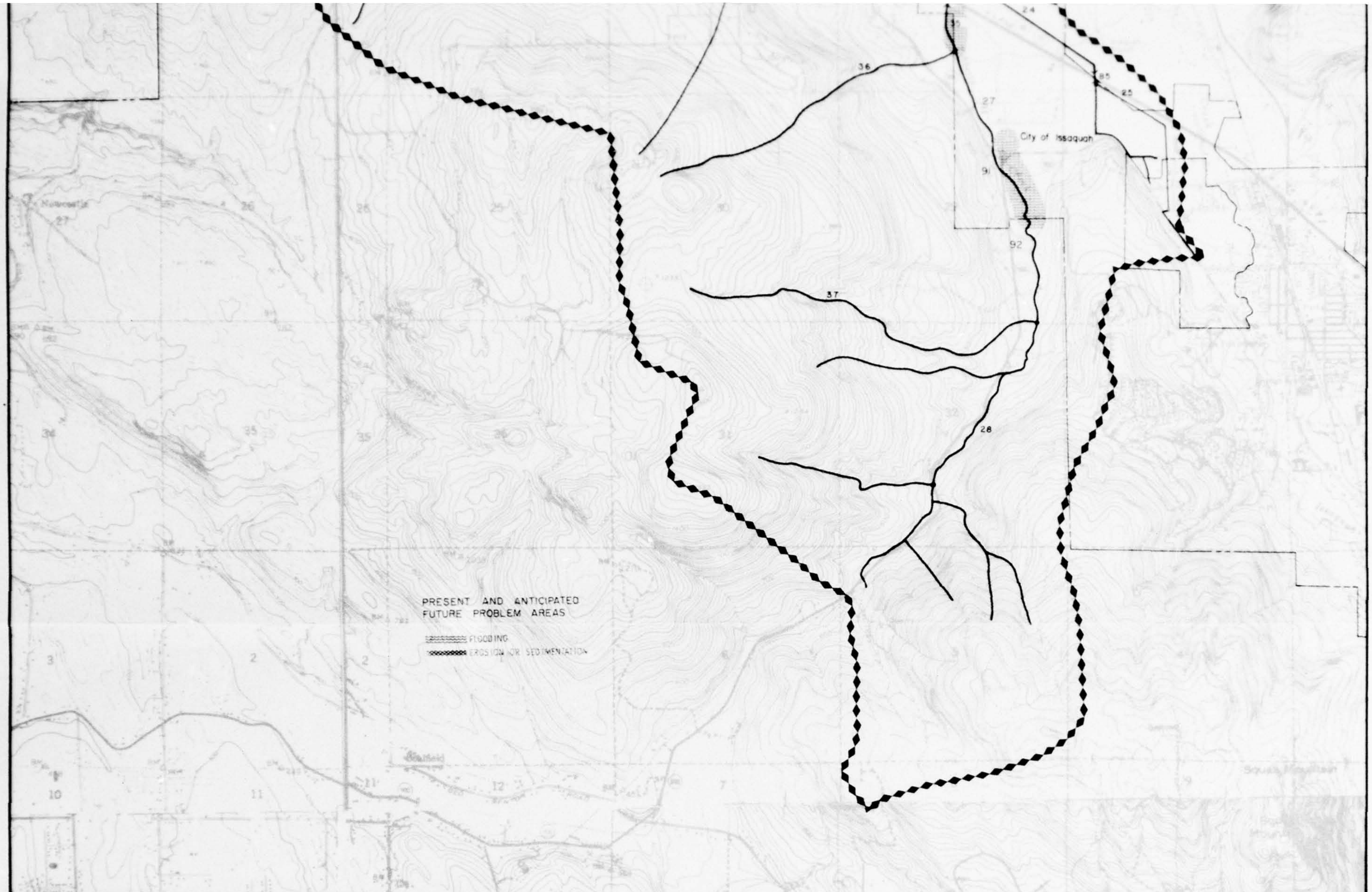
KRAMER, CHIN AND MAYO, INC
WATER RESOURCES ENGINEERS, INC
YODER, TROTTER, ORLOB & ASSOCIATES

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO E-26-1-161 SHEET 2 OF 3

2


MATCH LINE
S A M M A M I S H
L A K E
City of Bellevue
City of Issaquah
29
30
31
32
33
36
38
39
40
86
87
110
111



LEGEND

- SUB-BASIN BOUNDARY
- EXISTING CHANNEL
- EXISTING CONDUIT
- MANHOLE, INLET, OR JUNCTION
- CHANNEL OR CONDUIT DESIG. 5
- CITY LIMITS
- COUNTY (METRO) BOUNDARY
- LEVEE
- CULVERT
- HOLDING POND OR LAKE

N

1/2 1/4 0 1 MILES

1000 500 0 4000 FEET

NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

LAKE SAMMAMISH

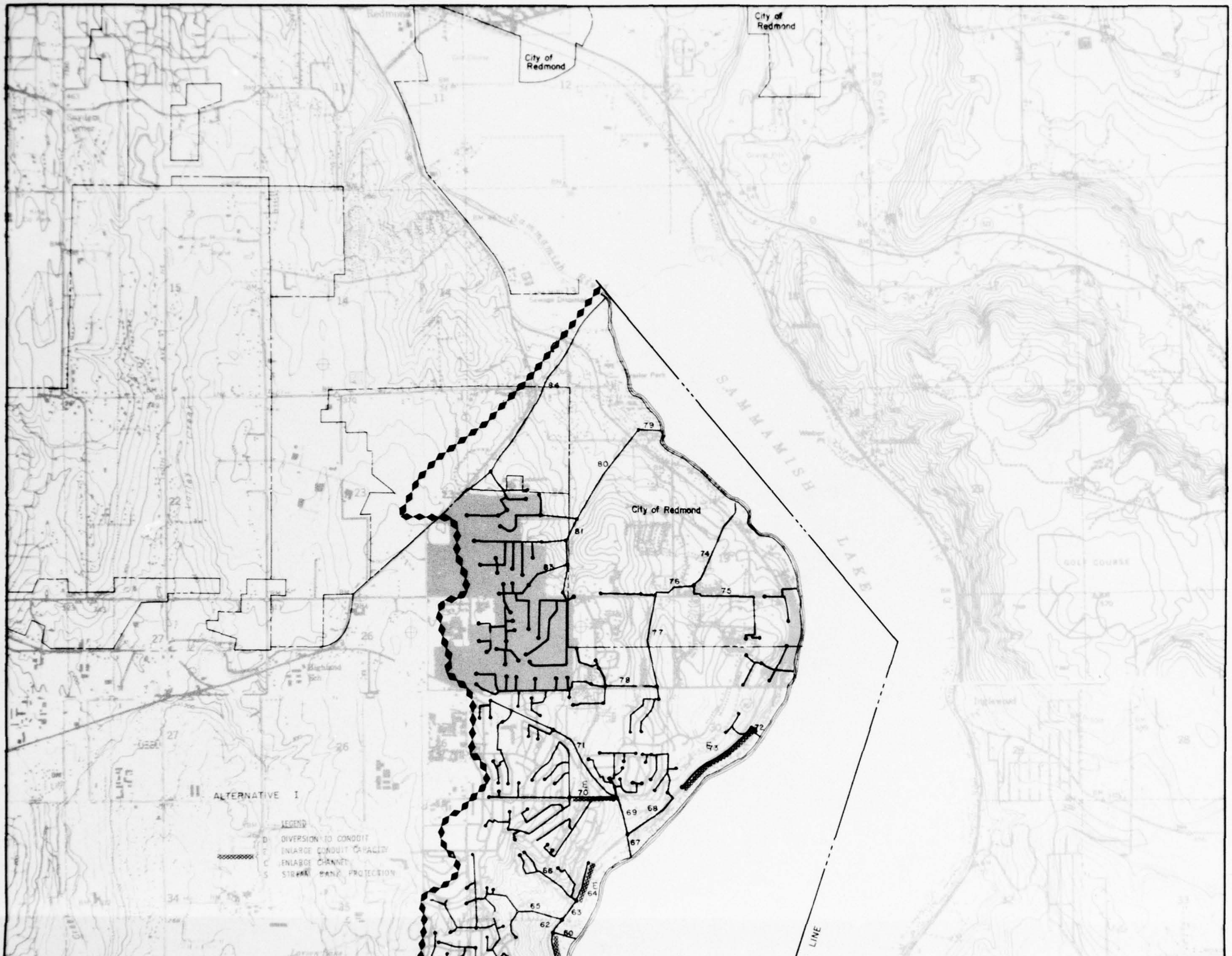
PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF *THE RIVER BASIN COORDINATING COMMITTEE (RIBCO)* AND THE METRO COUNCIL

KRAMER, CHIN AND MAYO, INC.
WATER RESOURCES ENGINEERS, INC.
YODER, TROTTER, ORLOB & ASSOCIATES

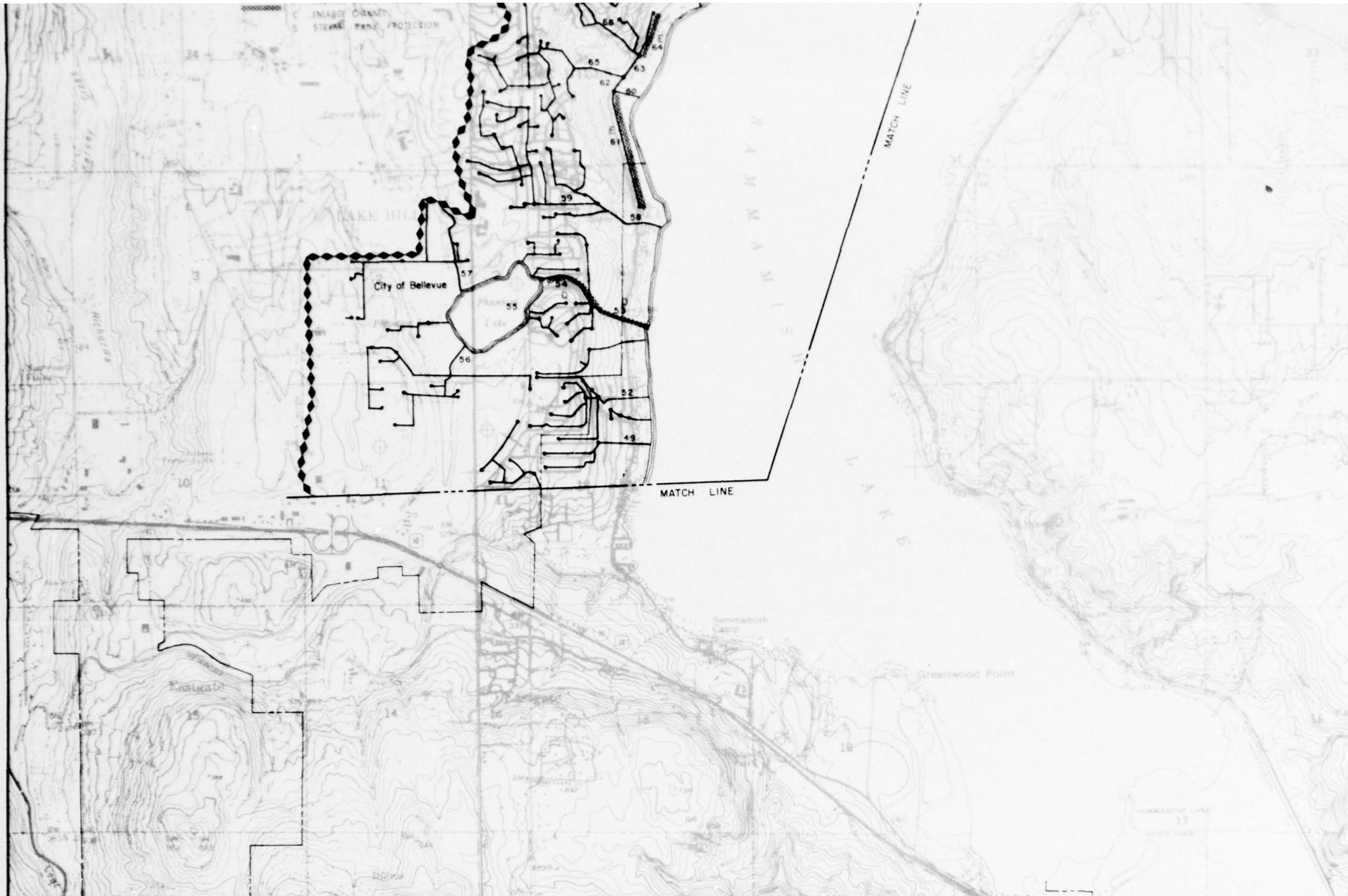
U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO. E-26-1-161 SHEET 3 OF 3

2



City of Redmond
City of Redmond
City of Redmond
SAMMAMISH LAKE
MATCH LINE
GOLF COURSE
ALTERNATIVE I
LEGEND
D DIVERSION TO CONDUIT
E ENLARGE CONDUIT CAPACITY
C ENLARGE CHANNEL
S STREAM BANK PROTECTION



LEGEND

SUB-BASIN BOUNDARY	
EXISTING CHANNEL	
EXISTING CONDUIT	
MANHOLE, INLET, OR JUNCTION	•
CHANNEL OR CONDUIT DESIG.	5
CITY LIMITS	
COUNTY (METRO) BOUNDARY	
LEVEE	
CULVERT	
HOLDING POND OR LAKE	

N

1/2 1/4 0 1
MILES

1000 500 0 4000
FEET

NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

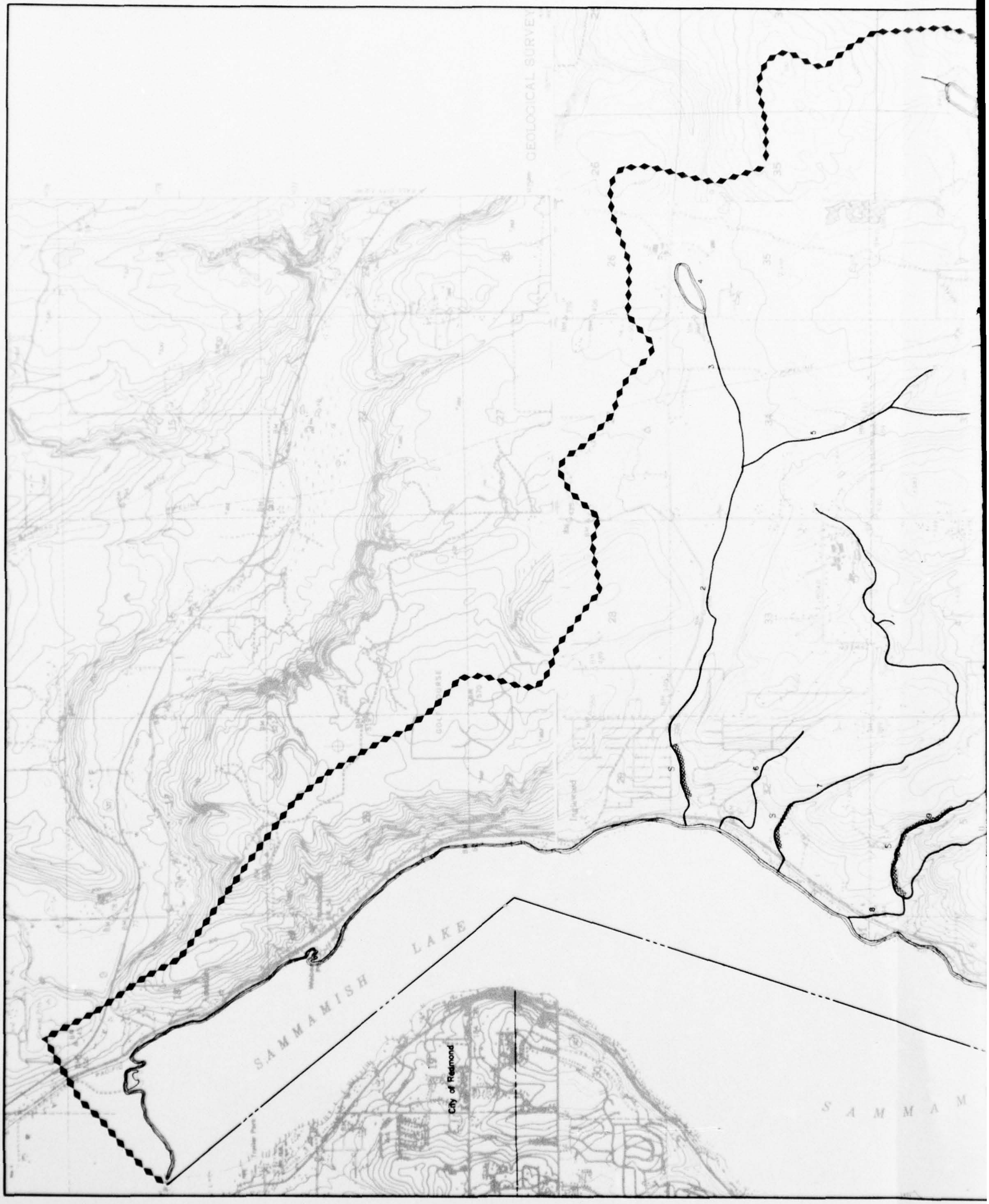
LAKE SAMMAMISH

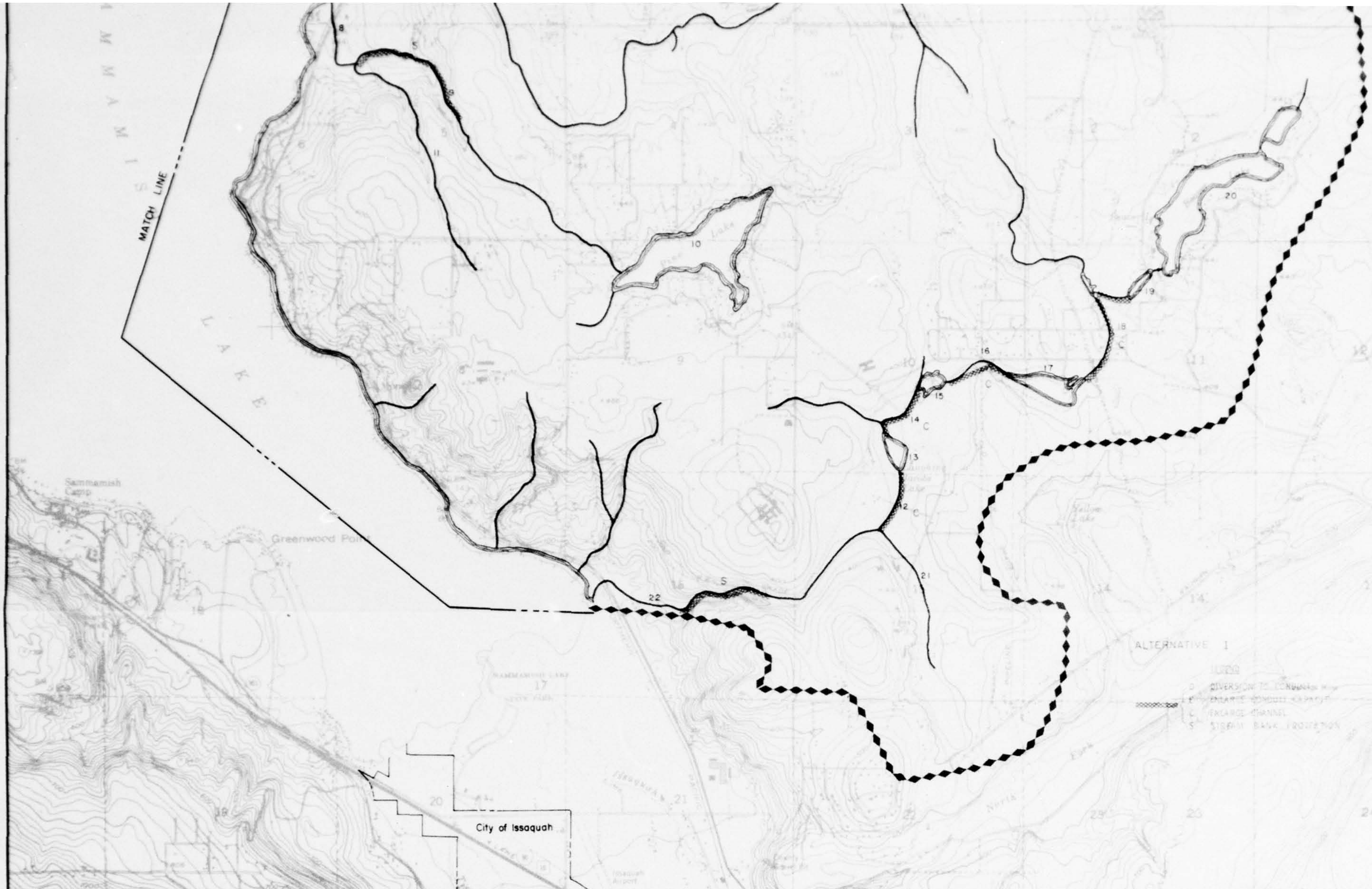
PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

KRAMER, CHIN AND MAYO, INC
WATER RESOURCES ENGINEERS, INC
YODER, TROTTER, ORLOB & ASSOCIATES

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO E-26-1-161 SHEET 1b OF 3


GEOLOGICAL SURVEY
SAMMAMISH LAKE
City of Redmond
SAMMAM



LEGEND

SUB-BASIN BOUNDARY
EXISTING CHANNEL
EXISTING CONDUIT
MANHOLE, INLET, OR JUNCTION
CHANNEL OR CONDUIT DESIG. 5
CITY LIMITS
COUNTY (METRO) BOUNDARY
LEVEE

CULVERT
HOLDING POND OR LAKE

N

1/2 1/4 0 1 MILES

1000 500 0 4000 FEET

NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

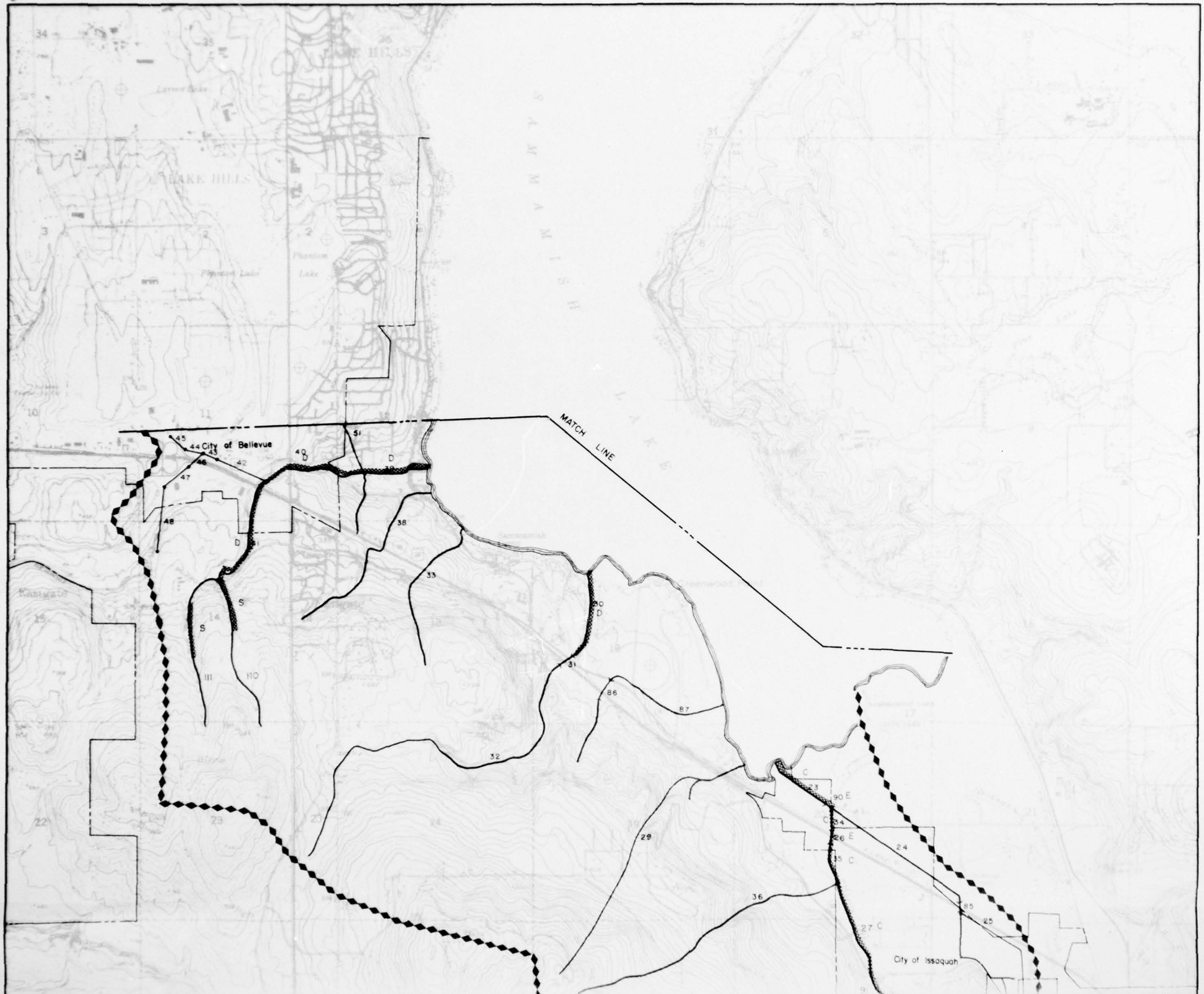
LAKE SAMMAMISH

PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

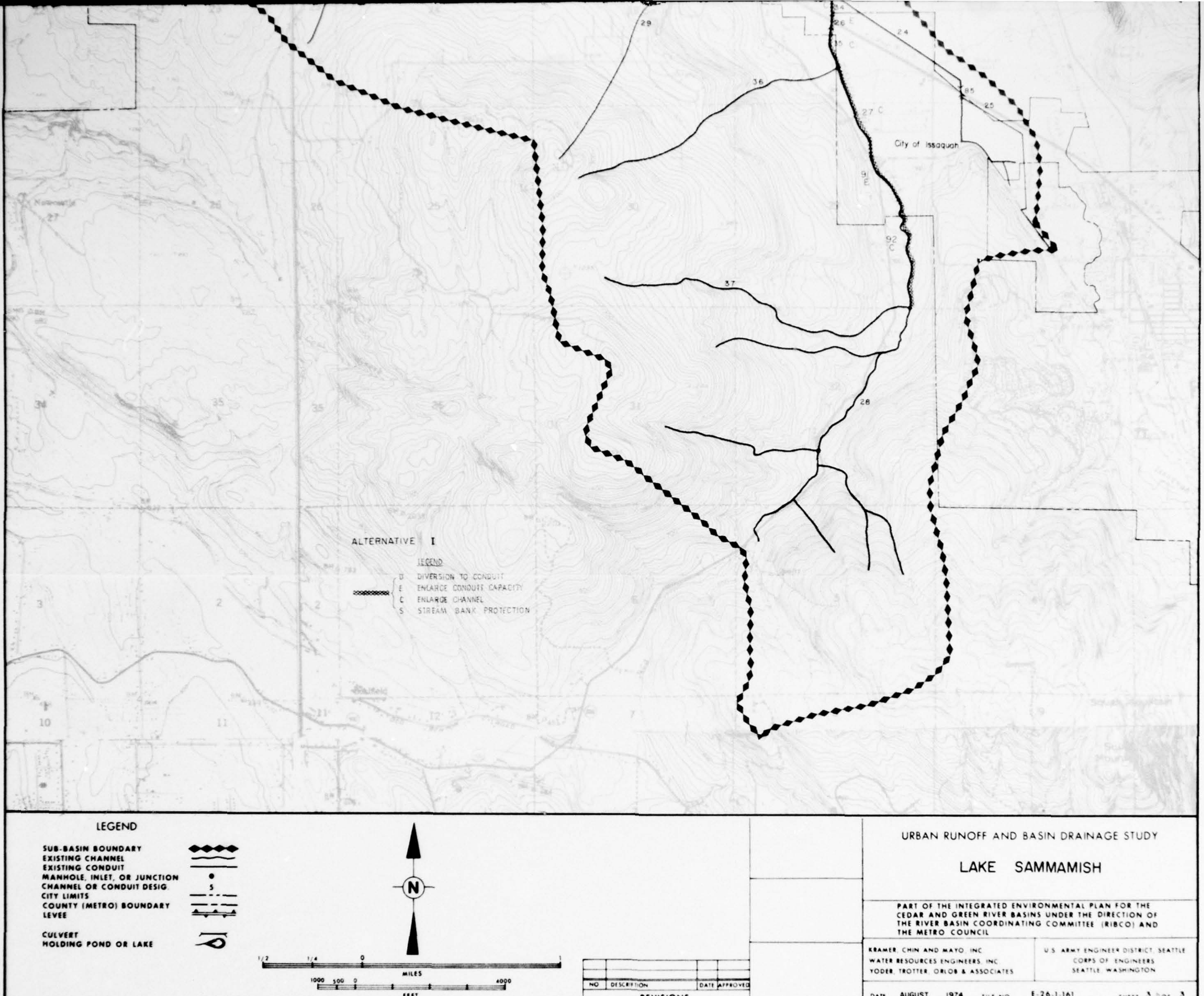
KRAMER, CHIN AND MAYO, INC
WATER RESOURCES ENGINEERS, INC
YODER, TROTTER, ORLOB & ASSOCIATES

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO. E-26-1-161 SHEET 2B OF 3



MATCH LINE
SAMMAMISH LAKE
LAKE HILLS
City of Bellevue
City of Issaquah



NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

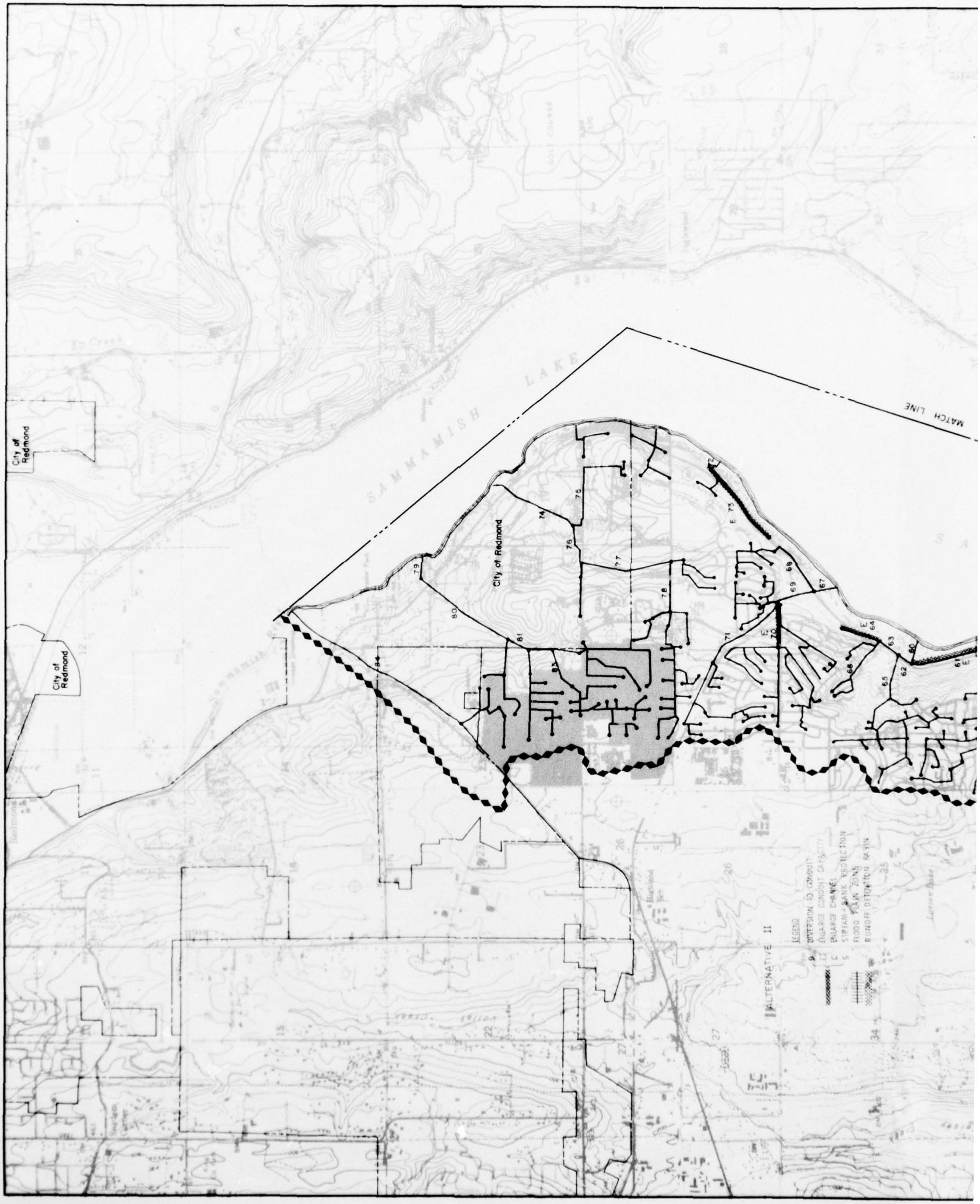
LAKE SAMMAMISH

PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

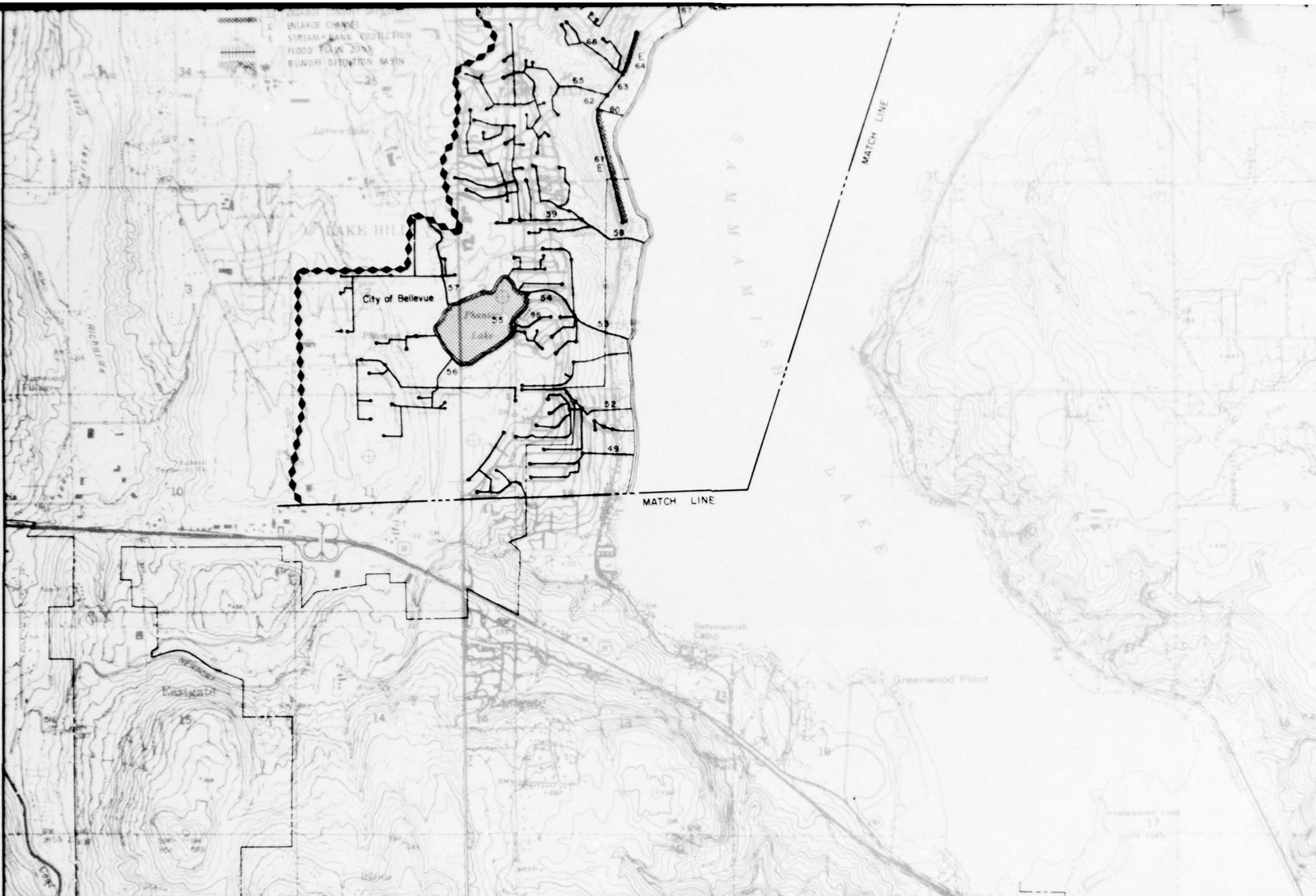
KRAMER, CHIN AND MAYO, INC.
WATER RESOURCES ENGINEERS, INC.
YODER, TROTTER, ORLOB & ASSOCIATES

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO. E-26-1-161 SHEET 3 OF 3



City of Redmond
SAMMAMISH LAKE
MATCH LINE
ALTERNATIVE II
LEGEND
DIVERSION TO CONDUIT
ENLARGE CONDUIT CAPACITY
ENLARGE CHANNEL
STREAM-BANK PROTECTION
FLOOD PLAIN ZONING
RUNOFF DETENTION BASIN



LEGEND

SUB-BASIN BOUNDARY	
EXISTING CHANNEL	
EXISTING CONDUIT	
MANHOLE, INLET, OR JUNCTION	
CHANNEL OR CONDUIT DESIG.	5
CITY LIMITS	
COUNTY (METRO) BOUNDARY	
LEVEE	
CULVERT	
HOLDING POND OR LAKE	

1/2 1/4 0 1
MILES

1000 500 0 4000
FEET

NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

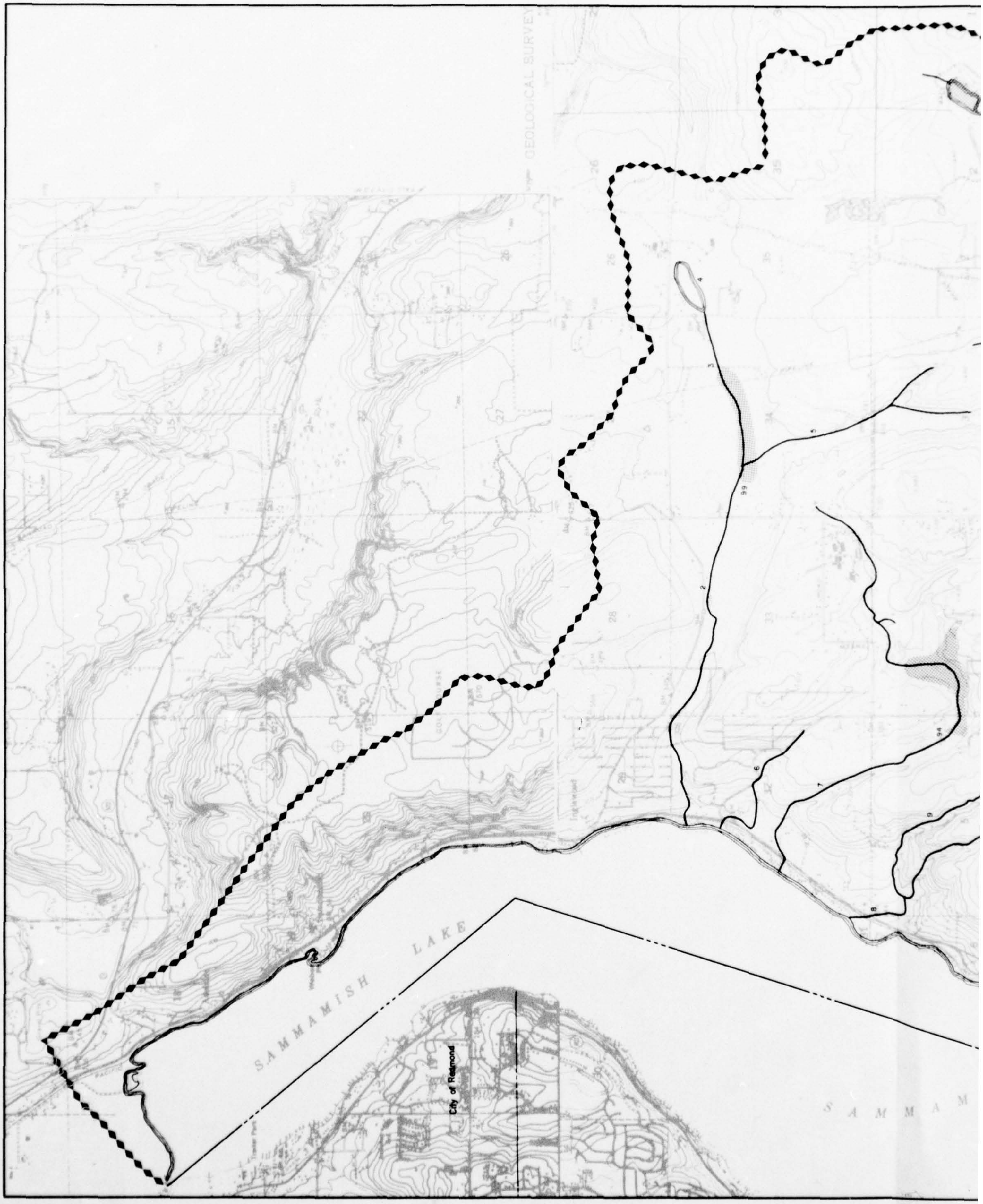
LAKE SAMMAMISH

PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

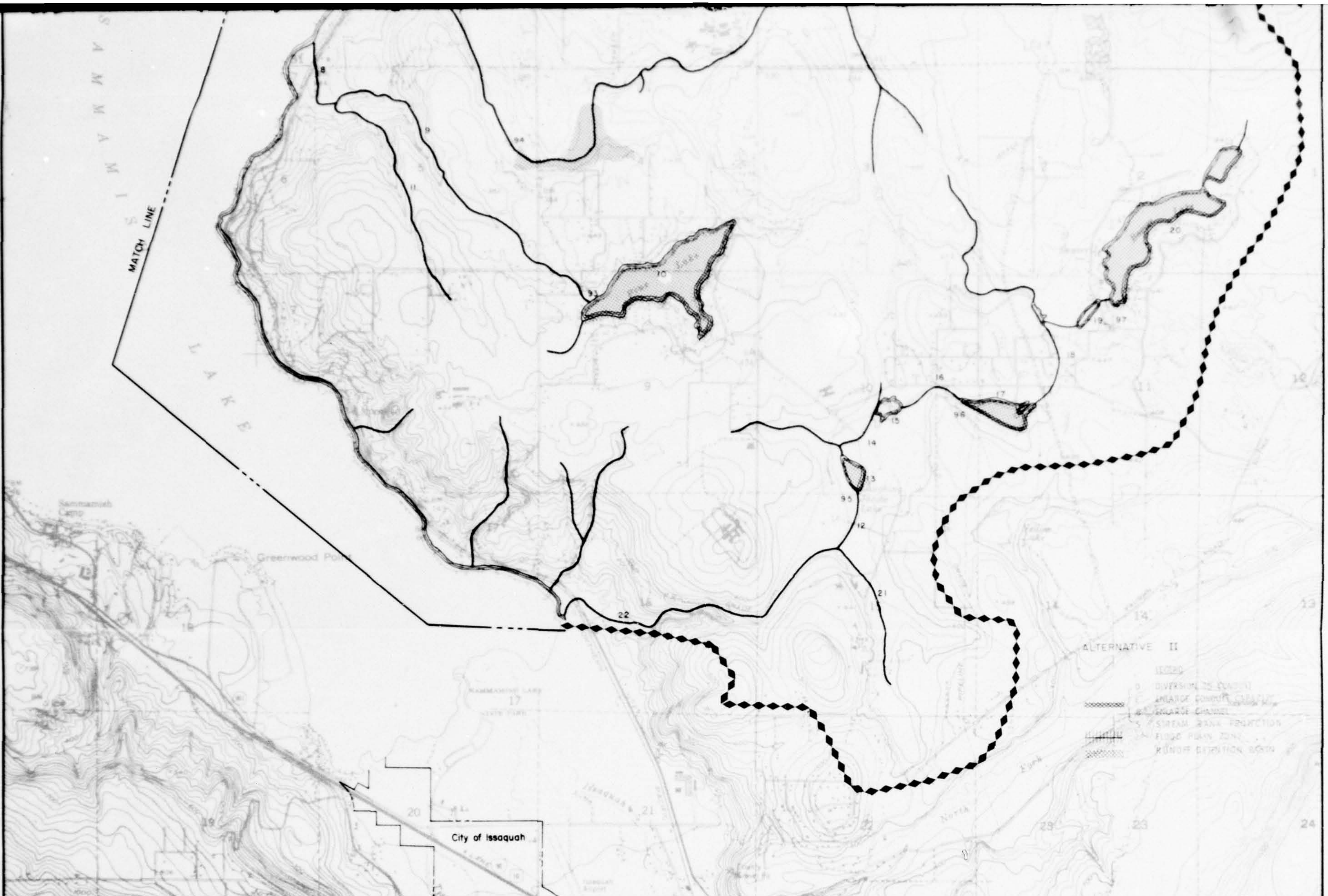
KRAMER, CHIN AND MAYO, INC
WATER RESOURCES ENGINEERS, INC
YODER, TROTTER, ORLOB & ASSOCIATES

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO E-26-1-161 SHEET [illegible] OF 3



GEOLOGICAL SURVEY
SAMMAMISH LAKE
SAMMAM
City of Redmond



LEGEND

- SUB-BASIN BOUNDARY
- EXISTING CHANNEL
- EXISTING CONDUIT
- MANHOLE, INLET, OR JUNCTION
- CHANNEL OR CONDUIT DESIG. 5
- CITY LIMITS
- COUNTY (METRO) BOUNDARY
- LEVEE
- CULVERT
- HOLDING POND OR LAKE

N

MILES: 1/2 1/4 0 1

FEET: 1000 500 0 4000

NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

LAKE SAMMAMISH

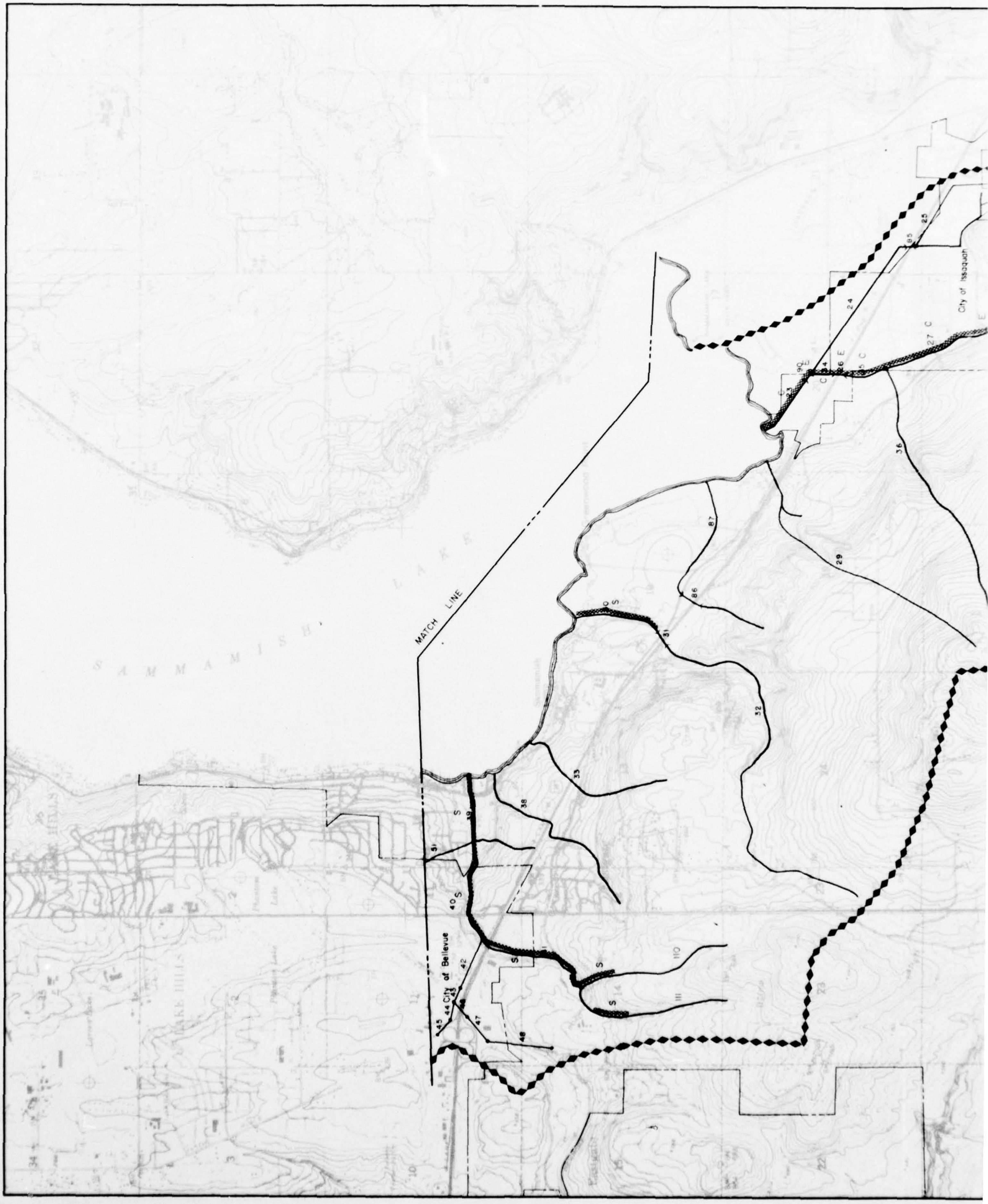
PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

KRAMER, CHIN AND MAYO, INC.
WATER RESOURCES ENGINEERS, INC.
YODER, TROTTER, ORLOB & ASSOCIATES

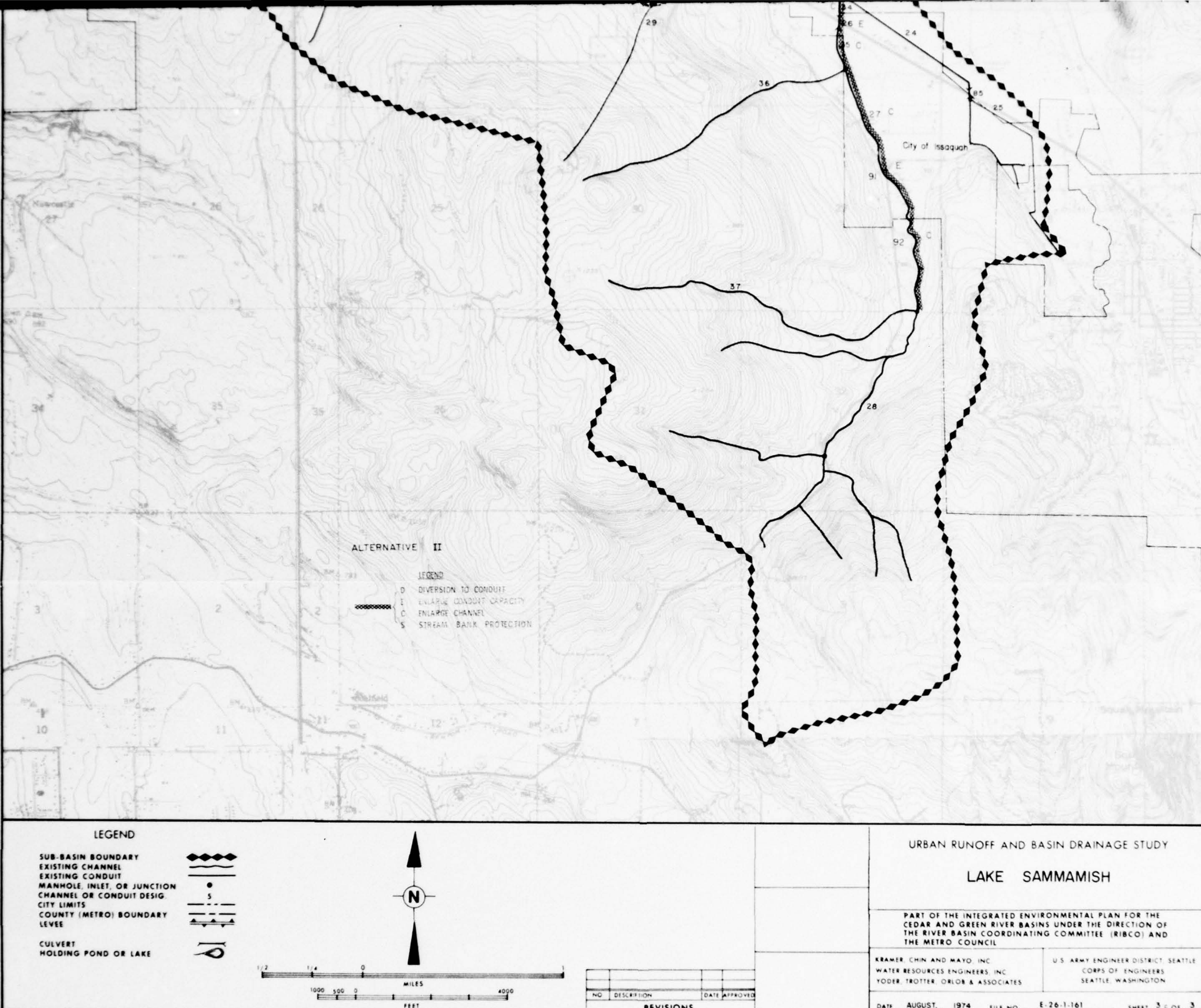
U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO. E-26-1-161 SHEET 2 OF 3

2



SAMMAMISH LAKE
MATCH LINE
City of Bellevue
City of Issaquah



NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

LAKE SAMMAMISH

PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

KRAMER, CHIN AND MAYO, INC
WATER RESOURCES ENGINEERS, INC
YODER, TROTTER, ORLOB & ASSOCIATES

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO E-26-1-161 SHEET 3 of 3

REGIONAL SUB-BASIN C-5

EVANS CREEK

GENERAL DESCRIPTION

The Evans Creek Sub-Basin, north of Lake Sammamish and east of the Sammamish River in the Cedar River basin, is approximately 13 miles long and three and a half miles wide. It is bounded on the north and east by the Cedar River and the Snoqualmie River divide, by Lake Sammamish and Redmond on the south and by Sammamish River on the west. The sub-basin is composed of two basic drainage systems, Bear Creek and Evans Creek.

Bear Creek (Called Bear Creek near Redmond)

The Bear Creek drainage area is orientated in a north-south direction. The sub-basin is bordered by the Cedar River-Snoqualmie River divide on its north and east, the Sammamish River on the west and the Evans Creek watershed on the south. The upper portion of the sub-basin is characterized by moderate to steeply sloped uplands draining into flood plains, wetlands or lakes. The lower portion of the watershed differs in geologic formation and exhibits a widening flood plain.

Bear Creek's drainage system is composed of two parallel stream and lake systems that converge approximately three and a half miles northeast of Redmond. The two systems are the Bear Creek and the Cottage Lake Creek drainage systems. Bear Creek's origin is Echo Lake. Bear Creek then drains through Paradise Lake and is joined by several tributaries, two of which are Struve Creek and Seidel Creek, before being met by Cottage Lake Creek. Little Lake, Crystal Lake and its associated wetlands are the origin of the Cottage Lake drainage system. Daniel Creek, the upper-most stream of the system, drains the Crystal Lake area into Cottage Lake. Cottage Lake Creek drains Cottage Lake and after being joined by a tributary from Lake Leota it combines with Bear Creek. Bear Creek continues flowing south to join Evans Creek approximately one mile northeast of Redmond. The combined Bear-Evans Creek flows into the Sammamish River.

Evans Creek

The Evans Creek watershed drains in a northwesterly direction. The watershed is bordered by Bear Creek on the north, the Cedar River-Snoqualmie River divide on the east and the Lake Sammamish watershed on the west and south. Evans Creek originates in Peterson Pond, northeast of Lake Sammamish and drains south into a major wetlands area below the Redmond-Fall City Road. Evans Creek then flows northwesterly to join Bear Creek northeast of Redmond. Evans Creek then flows southwest parallel to SR-520, presently under construction, to drain into the Sammamish River south of Redmond.

Principal streams are categorized below.

Streams	Category	Drainage Area	Point of Discharge
Daniels Creek	III	2.0 sq. mi.	Cottage Lake
Cottage Lake Creek	III	12.7 sq. mi.	Bear Creek
Struve Creek	III	1.9 sq. mi.	Bear Creek
Seidel Creek	III	2.7 sq. mi.	Bear Creek
Bear Creek	III	12.4 sq. mi.	Evans Creek
Evans Creek (above confluence with Bear Creek)	I	15.4 sq. mi.	

Present development in the Bear Creek sub-area consists of scattered rural single-family residences along the middle and upper sections of Bear and Cottage Lake Creeks. Evans Creek sub-area is presently rural single-family residential and undeveloped land. Below the confluence of Bear and Evans Creeks, land use is agricultural, industrial and recreational.

Existing and predicted land use within the sub-basin is summarized below:

PERCENT OF SUB-BASIN AREA IN SPECIFIED LAND USE

Land Use	Existing (1970-72)	P.S.G.C. Land Use Projection Comprehensive	Corridor
Single Family	20	64	52
Multiple Family			1
Commercial/Services		1	1
Govt. and Educ.		1	1
Industrial		3	4
Parks/Dedicated Open Space	5	10	10
Agriculture	10		
Airports, Railyards, Freeways, Highways			

Land Use	Existing (1970-72)	P.S.G.C. Land Use Projection Comprehensive	Corridor
Unused Land	64	20	30
Water	1	1	1
Total	100	100	100
Total Impervious Area	5	25	20

The jurisdictions involved in the Evans Creek sub-basin are: King County, 70% of land area; Snohomish County, 29% and Redmond 1%. The sub-basin is partially within Metro's service area. A King County Flood Control Zone District has been formed within the Evans Creek watershed. A citizens' group, The Bear Creek Valley Association, has taken active interest in projects within the sub-basin.

Future development trends indicate general urbanization by single-family residences of the Bear Creek area. The lower section of Evans Creek, and below the confluence of Evans and Bear Creeks, is expected to industrialize with a small portion of the area to remain in recreational and single-family residential use. Extension of State Route 520 into Redmond will significantly affect urban growth within the sub-basin.

NATURE OF EXISTING DRAINAGE SYSTEM

Evans Creek is in a relatively natural condition except for 3500 feet upstream from the confluence with the Sammamish River that has been channelized and will be parallel to the new section of SR 520. Evans Creek is natural except for occasional road culverts. Crystal Lake's elevation is controlled by abutting property owners. This control also affects the flow of Daniel Creek. Otherwise, neither stream has been channelized, rip-rapped or otherwise controlled by drainage structures to a significant degree.

This drainage system is a valuable natural resource. Its lakes and wetlands are extensive wildlife habitats. Bear Creek is an excellent producer of coho, chinook and sockeye salmon as the stream system is extensive and the level of development is low. Maximum accessibility adds recreational value.

DRAINAGE PROBLEMS

At present, the sub-basin is relatively free of significant urban runoff problems. The lower section has high water tables, but the cause is natural. Coliform counts in Cottage Lake and the streams are high because there are no sewers in the sub-basin and because pastures for horses and cattle are adjacent to the streams.

Increased development in the sub-basin, without runoff control, would cause flooding, erosion and degradation of the water quality due to greater stream-flow fluctuations. If this development occurs as projected in the future land-use plans, the wetlands of both Crystal Lake and Evans Creek will be lost.

The results of hydrologic analyses in the Evans Creek Sub-Basin indicate no significant difference between the Comprehensive and Corridor Land Use Plans; therefore, the drainage alternatives presented here are applicable to both plans.

BASIC ISSUES AND STATUS OF DRAINAGE PLANNING

Presently, the three agencies that have urban drainage planning authority in the Evans Creek Sub-Basin are King County, Snohomish County and the City of Redmond. King County has prepared a drainage plan for the Evans Creek Flood Control Zone District that proposes conventional structures such as creek channels and closed conduits, but lack of funds and a low County priority has delayed implementation by the Evans Creek Flood Control Zone District. The County intends to modify this plan to accommodate changes in the sub-basin before its implementation. King County is working with the citizens adjacent to Cottage Lake in an effort to control the lake level. The Corps of Engineers prepared a Flood Hazard Information Study for Redmond and King County in 1970 covering the combined Evans-Bear Creek System.

Because development in the Evans Creek Sub-Basin is not yet extensive, new techniques for drainage management can be applied effectively, including runoff control, flood-plain zoning and proper land-use planning. Conversely, if development brings conventional closed conduits that discharge directly to the streams and if development encroaches upon the flood plain, stream channelization will be required that will cause significant environmental degradation.

Members from the King County Public Works Department, Hydraulics Division, the Snohomish County Engineering and Planning Departments, and representatives from the City of Redmond, Public Works, Engineering and Planning Departments, jointly reviewed the initial alternative plans for drainage development of this RIBCO Study for the Evans Creek Sub-Basin.

ALTERNATIVE PLANS FOR PROPOSED DRAINAGE CONTROL

The existing drainage system of the Evans Creek Sub-Basin, as described by local agencies, was evaluated by computer simulation that applied the region's 10-year storm to the year 2000 land use. Drainage problems thus identified were analyzed and possible solutions were provided in development of alternative plans for drainage control as described below.

The two major alternative plans were studied for solving the Evans Creek drainage problems. The first made use of holding ponds and flood-plain zoning in addition to runoff control. Description of these two alternatives follows.

ALTERNATIVE PLAN I

General Concept

The concept consists primarily of two elements, holding ponds and flood-plain zoning. It does not make use of the conventional urban drainage facilities such as conduit enlargement and streambank protection.

Major Features

Flooding, as indicated by computer simulation, began in all upstream elements of Evans, Bear and Cottage Lake Creeks and progressed downstream. To alleviate this flooding, twelve holding ponds are used. Two holding ponds are located on Evans Creek, three holding ponds are located on Bear Creek, one holding pond is located on Seidel Creek, a tributary to Bear Creek, two holding ponds are located on Cottage Lake Creek, and four holding ponds are located on its tributaries. The locations of the holding ponds were selected so that they occurred in natural wetland depressions, were distant from major residential areas, and were located near roads to facilitate construction, operation and maintenance.

Flood plain zoning is used for all elements on the main streams of Evans, Bear and Cottage Lake Creeks.

Costs

Total estimated capital cost of this alternative plan is $1,700,000.

ALTERNATIVE PLAN II

General Concept

The concept of Alternative Plan II would be identical to Alternative Plan I except that land-use controls are added.

Major Features

The most significant feature of this alternative is that of land-use control. Development is restricted in the sub-basin so that runoff is limited to approximately the same runoff that would occur under present conditions.

Presently, King County has a storm drainage policy for land development that states "...drainage plans shall provide storm water retention facilities so that peak discharge from the site will not be increased by more than 25% due to the proposed development." Even with this policy in force, holding ponds and flood-plain zoning will be required in the Evans Creek Sub-Basin.

Holding ponds in this alternative are located in the same areas as in Alternative Plan I except for the removal of the one holding pond located on Seidel Creek; however, all others will be resized to obtain adequate capacity. Flood-plain zoning also will be used for the elements in Alternative Plan II as they are in Alternative Plan I.

Costs

The estimated total capital costs for this alternative is $900,000.

PEAK FLOW COMPARISONS

The following table indicates 10-year peak flows under existing facilities and under drainage management solutions for the year 2000.

COMPARISON OF 10-YEAR PEAK FLOWS
(Cubic Feet Per Second)

Location	Existing Facilities	Alternative Plan I	Alternative Plan II
Cottage Lake Creek at SR 202 & N.E. 55th Pl.	100	100	100
Cottage Lake Outflow	120	110	90
Cottage Lake Creek at Bear Creek	130	130	130
Below Confluence of Bear and Cottage Lake Creeks	310	310	210
Bear Creek at Confluence of Bear and Evans Creeks	310	310	190
Evans Creek at Confluence of Bear and Evans Creeks	370	370	240
Evans Creek Mouth	750	750	540

ENVIRONMENTAL ASSESSMENT OF ALTERNATIVE PLANS

Field inspections were made to judge the applicability of the suggested alternatives for this sub-basin. This procedure followed throughout the RIBCO Study for development of alternative plans for the various regional sub-basins. The inspections were based upon the alternative evaluation procedure which identified 34 unique criteria grouped in general categories as follows: 1) Effectiveness, 2) Human Values, 3)Environmental Factors, 4) Implementation, and 5) Resource Requirements.

The various structural solutions were checked against the appropriate criteria. The various non-structural solutions were reviewed for their relationship to existing and probable future developments. The criteria rating total for Alternative Plan I, which employs holding ponds and flood-plain zoning, was a plus 41 out of a possible range from a positive total of 108 and a negative total of 108. The total evaluation rating for Alternative Plan II, which employs holding ponds, flood-plain zoning and runoff control, was a plus 53.

Both alternative plans are judged to be effective in controlling drainage. Both plans involve certain sacrifices of human value and human uses of the plans once they are built. Environmentally, both alternative plans are given superior ratings. The only area in which Alternative Plan II is superior to Alternative Plan I is in the area of water quality whereby the lower flow rates in Alternative Plan II will improve water quality due to decreased erosion. Neither alternative is part of present planning by any of the involved agencies and therefore, extensive cooperative effort on their parts is required before either plan can be realized. Both of the alternative plans involve commitments of the use and management of natural resources because they both employ certain structural elements; however, Alternative Plan II involves considerably less use of natural resources because of its use of runoff control.

Because Alternative Plan II relies on flood plain zoning and runoff control from future land development, this treatment combination, if it is to be part of the chosen alternative, should be implemented as an early organized effort. Any portion of the sub-basin that develops without these combined controls will require more structural treatment than Alternative Plan II can accommodate. This issue should be brought to the attention of all citizens and their local agencies.

CONCLUSIONS

The concept presented by these two alternative plans is not the only way to alleviate flooding. One could, for example, use no holding ponds and use a diversion pipeline or simply excavate and concrete-line a channel that could convey the design flows. This concrete-line concept, used predominately during the past decades, is presently under critical review.

The more popular and contemporary concept of inter-relating a natural creek in the environment with man-made improvements, provides not only aesthetic usefulness but also a social value. Flood-plain zoning in these two alternatives is another special consideration. Presently many of the residents in the Evans Creek Sub-Basin already have flood-plain zoned their property by building their homes several hundred feet from the main stream and by locating sheds and other buildings (that could be flooded occasionally with no appreciable harm) nearer to the stream channel.

Both of these concepts provide a viable alternative for this predominately undeveloped sub-basin located near the metropolitan area of Seattle. The holding ponds provide not only a retention facility for peak flows but also tend to improve the quality of the water. Flood-plain zoning, which can easily be implemented because of the undeveloped land in this sub-basin, also is a viable method for minimizing flooding in future years.

The concept of land-use controls, which result in runoff control as used in Alternative Plan II, is a concept that generates many advantages for alleviation of drainage problems. First, it significantly reduces the cost of the proposed facilities by about $800,000; secondly, the reduced flow rates lessen the damage due, not only to flooding, but also water quality such as sedimentation.

King County, Snohomish County and the City of Redmond should establish an effective agreement for development of a master drainage plan, that incorporates the provisions of Alternative Plan II. These agencies should then move to implement and enforce the required runoff controls and flood-plain zoning within their own jurisdictions.

RUNOFF QUALITY SUMMARY
EVANS CREEK

BASED UPON A 10-YEAR STORM PRECEDED BY 15 DAYS WITH LITTLE OR NO RAINFALL#

LOCATION	ALTERNATIVE PLAN	PEAK FLOW (cfs)	CONCENTRATION AT PEAK FLOW*				
			BOD	TOTAL COLIFORM	NH_3	$NO_2 + NO_3$	PO_4
Mouth of Creek	I	750	18	5.5×10^5	.9	1.9	.2
Mouth of Creek	II	540	24	7.9×10^5	1.2	2.4	.3

Less than a total of 0.5 inches of rainfall in any one day.
* Concentrations in mg/liter except total coliform which is in MPN/100 ml.

EVALUATION MATRIX

EVANS CREEK

ALTER-NATIVES	SUB TOTAL	EFFECTIVENESS								SUB TOTAL	HUMAN VALUES							SUB TOTAL	ENVIRONMENTAL FACTORS									SUB TOTAL	IMPLEMENTATION						SUB TOTAL	RESOURCE REQUIREMENTS				RATING TOTAL
		Use of existing facilities	System reliability	System maintainability	System flexibility	Flood damage reduction	Consequences of overcharge	Erosion and sedimentation control	Cost/benefits ranking		Urban quality (aesthetics)	Effect on land use	Displacement of people	Educational value	Community cohesion	Multiple use potential	Public health and safety		High flow conditions	Alteration of natural system	Effects on groundwater	Low flow conditions	Water quality	Construction disruption	Effects on wildlife	Effects on aquatic life	Effects on vegetation		Legislative requirements	Jurisdictional	Land acquisition	Public acceptance	Financing	Effects of no action		Energy	Materials	Land	Capital	
		CRITERIA WEIGHT									CRITERIA WEIGHT								CRITERIA WEIGHT										CRITERIA WEIGHT							CRITERIAWEIGHT				
		1	4	3	2	4	4	4	2		4	2	2	1	3	3	4		4	4	4	4	4	2	4	4	4		4	4	2	4	4	3		3	3	2	2	
I	+11									+5								+24										-2							+3					+41
II	+17									+5								+28										-2							+5					+53

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative I Sub-Basin Evans Creek

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
100	None					Holding Pond	70 AF 70 acres Outlet pipe 48"	$414,000
103	None					Holding Pond	23 AF 23 acres Outlet pipe 60"	$148,000
27		Small lake with uncontrolled outlet				Holding Pond	2 AF Pump Outlet pipe 48"	$33,000
105	None					Holding Pond	23 AF 23 acres Outlet pipe 48"	$155,000
108	None					Holding Pond	8 AF 8 acres Outlet pipe 42"	$70,000
110	None					Holding Pond	23 AF 23 acres Outlet pipe 60"	$148,000
115	None					Holding Pond	11 AF 11 acres Outlet pipe 48"	$86,000
117	None					Holding Pond	12 AF 12 acres Outlet pipe 48"	$493,000
16		Small lake with uncontrolled outlet				Holding Pond	11 AF Pump Outlet pipe 42"	$33,000
18		Small lake with uncontrolled outlet				Holding Pond	1 AF Pump Outlet pipe 36"	$33,000
121	None					Holding Pond	3 AF 3 acres Outlet pipe 12"	$37,000
21		Small lake with uncontrolled outlet				Holding Pond	28 AF Pump Outlet pipe 18"	$33,000

The Estimated Capital Cost for each element includes Contractor profit, engineering, legal and contingencies. In addition, land purchase and severance costs are included where land is required. All costs are based upon June 1973 prices.

Total Estimated Capital Cost: $1,683,000

Round To: $1,700,000

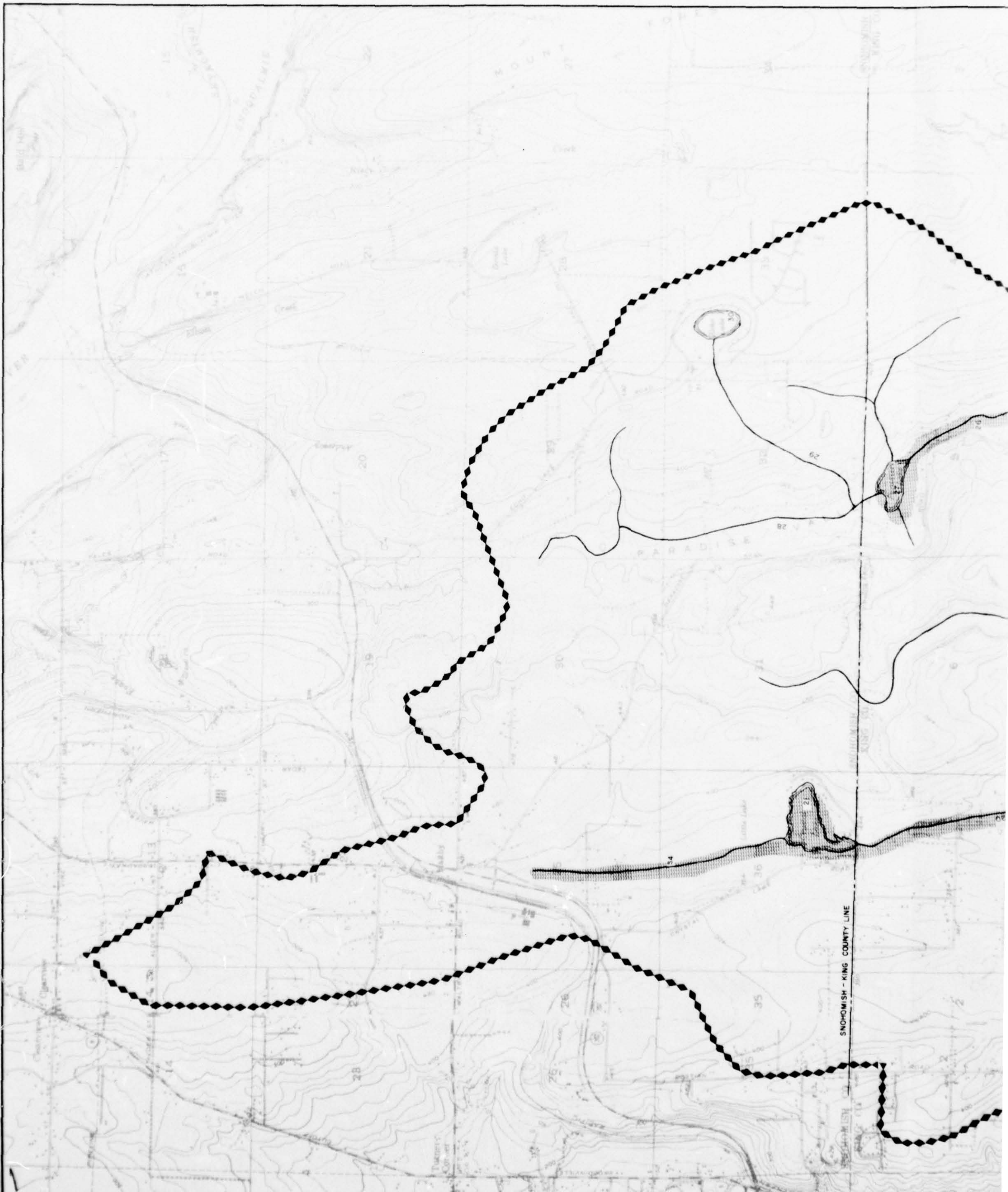
RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative II Sub Basin Evans Creek

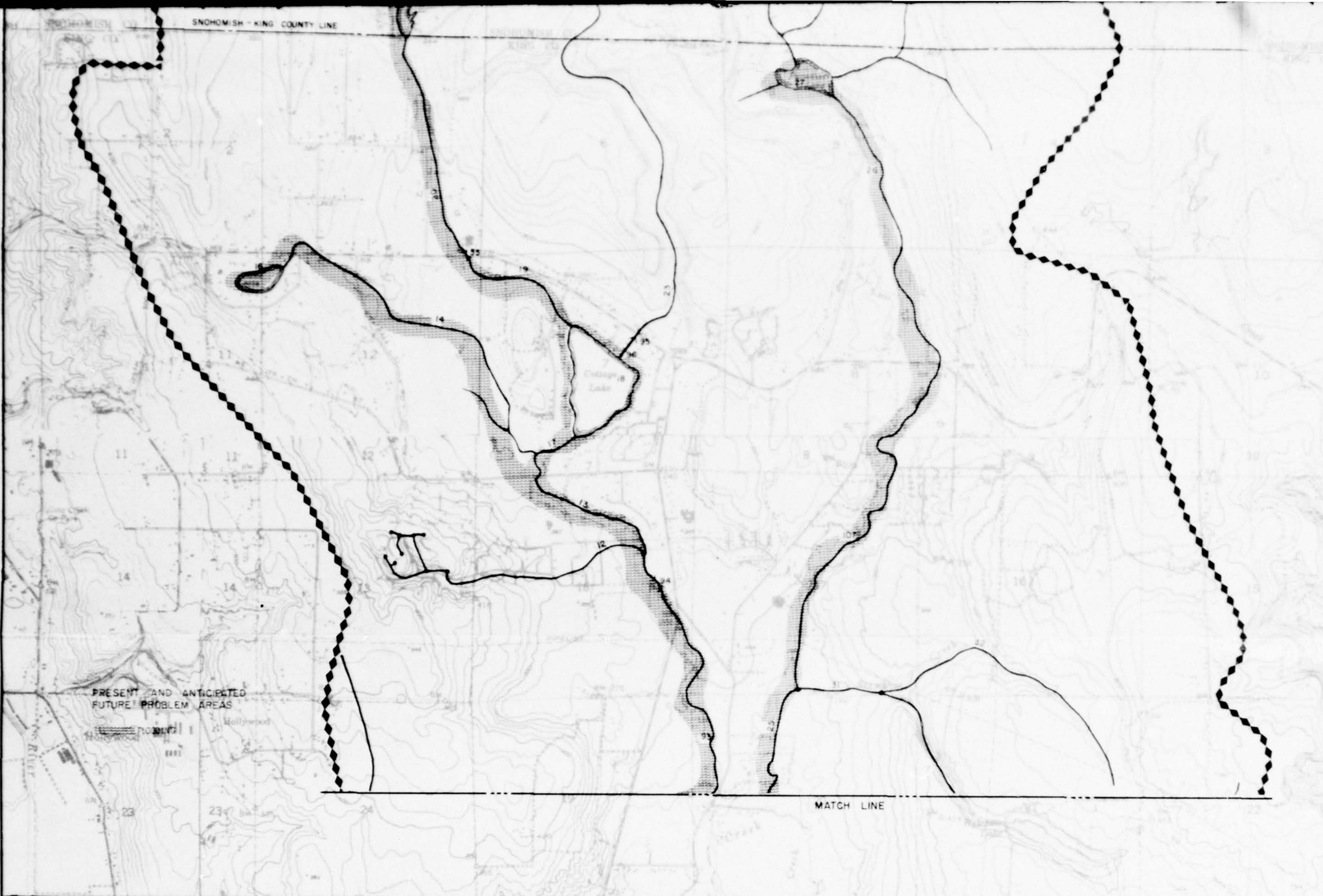
ELEMENT NUMBER	EXISTING FACILITIES: TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz. Vert.)	MAX. DEPTH OF CHANNEL	PROPOSED FACILITIES: TYPE		ESTIMATED CAPITAL COST
100	None					Holding Pond	28 AF 28 acres Outlet pipe 48"	$182,000
103	None					Holding Pond	6 AF 6 acres Outlet pipe 60"	$59,000
27		Small lake with uncontrolled outlet				Holding Pond	2 AF Pump Outlet pipe 48"	$33,000
105	None					Holding Pond	18 AF 18 acres Outlet pipe 48"	$123,000
110	None					Holding Pond	8 AF 8 acres Outlet pipe 60"	$70,000
115	None					Holding Pond	6 AF 6 acres Outlet pipe 48"	$59,000
117	None					Holding Pond	5 AF 5 acres Outlet pipe 48"	$218,000
16		Small lake with uncontrolled outlet				Holding Pond	1 AF Pump Outlet pipe 42"	$33,000
18		Small lake with uncontrolled outlet				Holding Pond	1 AF Pump Outlet pipe 36"	$33,000
121	None					Holding Pond	3 AF 3 acres Outlet pipe 12"	$44,000
21		Small lake with uncontrolled outlet				Holding Pond	18 AF Pump Outlet pipe 18"	$33,000

The Estimated Capital Cost for each element includes Contractor profit, engineering, legal and contingencies. In addition, land purchase and severance costs are included where land is required. All costs are based upon June 1973 prices.

Total Estimated Capital Cost $887,000
Round To: $900,000



PARADISE
SNOHOMISH - KING COUNTY LINE



LEGEND

SUB-BASIN BOUNDARY
EXISTING CHANNEL
EXISTING CONDUIT
MANHOLE, INLET, OR JUNCTION
CHANNEL OR CONDUIT DESIG
CITY LIMITS
COUNTY (METRO) BOUNDARY
LEVEE
CULVERT
HOLDING POND OR LAKE

N

1/2 1/4 0 1 MILES
1000 500 0 4000 FEET

NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

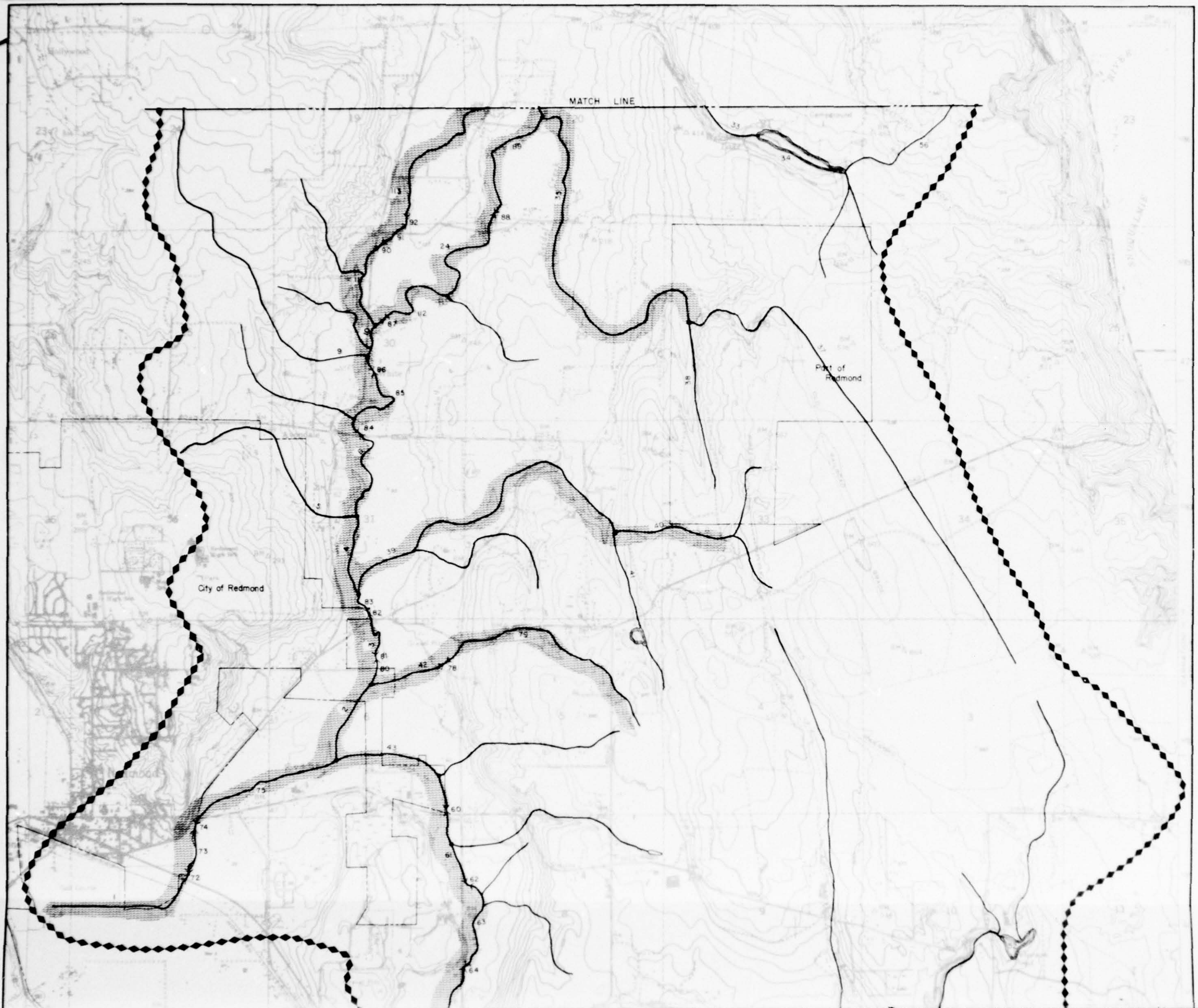
EVANS CREEK

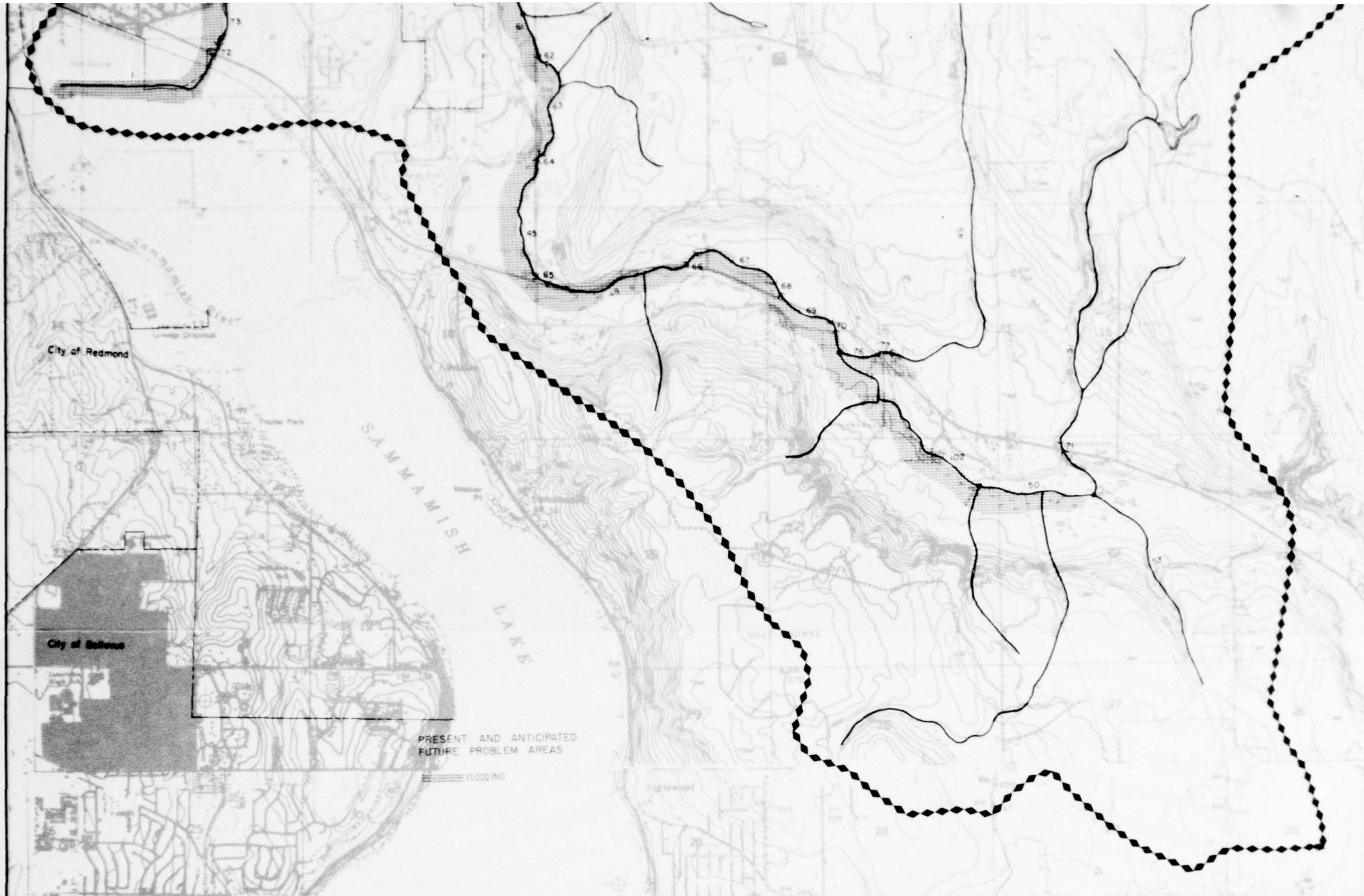
PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

KRAMER, CHIN AND MAYO, INC
WATER RESOURCES ENGINEERS, INC
YODER, TROTTER, ORLOB & ASSOCIATES

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO E-26-1-161 SHEET 1a OF 2


MATCH LINE
Port of Redmond
City of Redmond



LEGEND

SUB-BASIN BOUNDARY
EXISTING CHANNEL
EXISTING CONDUIT
MANHOLE, INLET, OR JUNCTION
CHANNEL OR CONDUIT DESIG. 5
CITY LIMITS
COUNTY (METRO) BOUNDARY
LEVEE

CULVERT
HOLDING POND OR LAKE

N

1/2 1/4 0 1
MILES
1000 500 0 4000
FEET

NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

EVANS CREEK

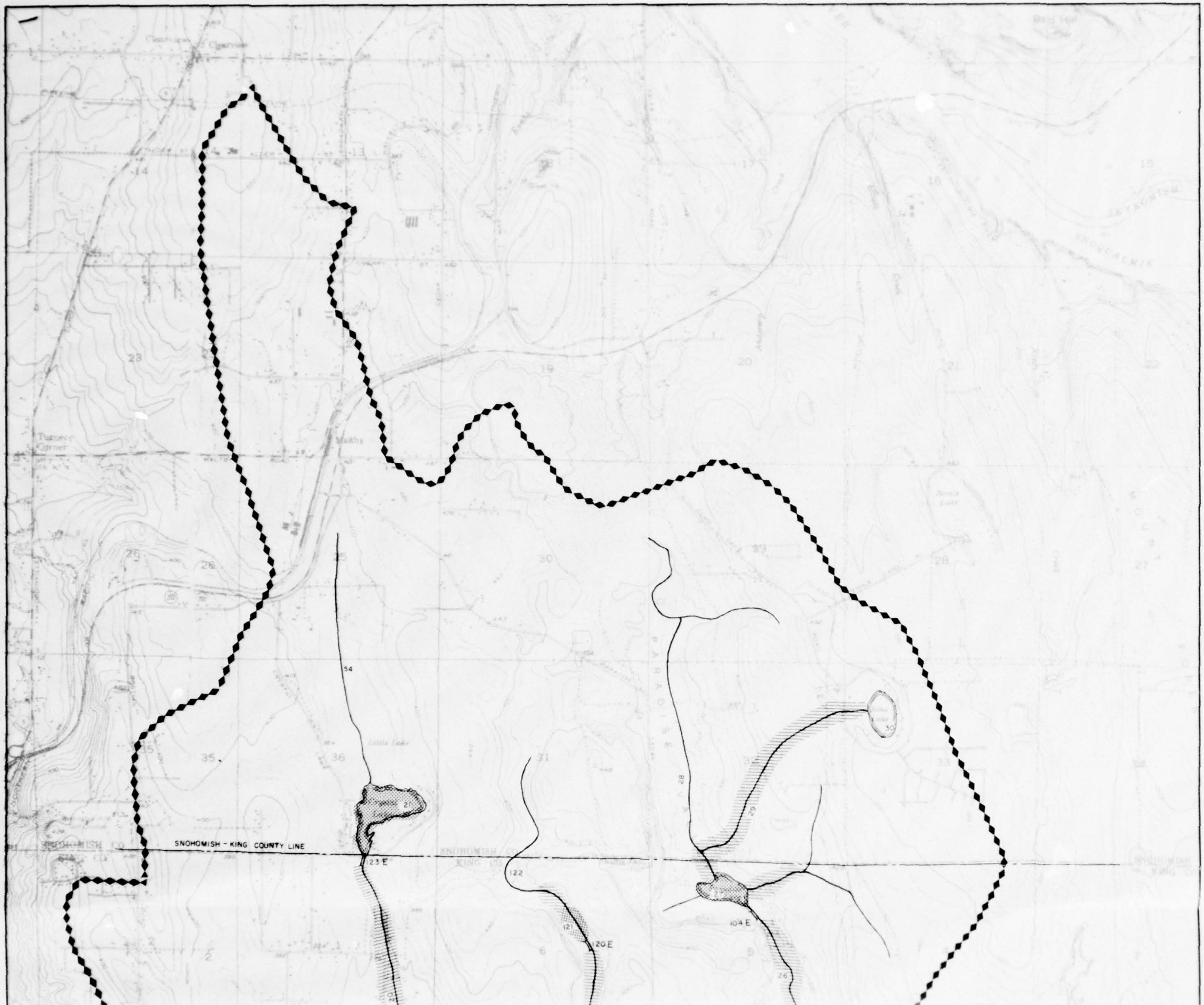
PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

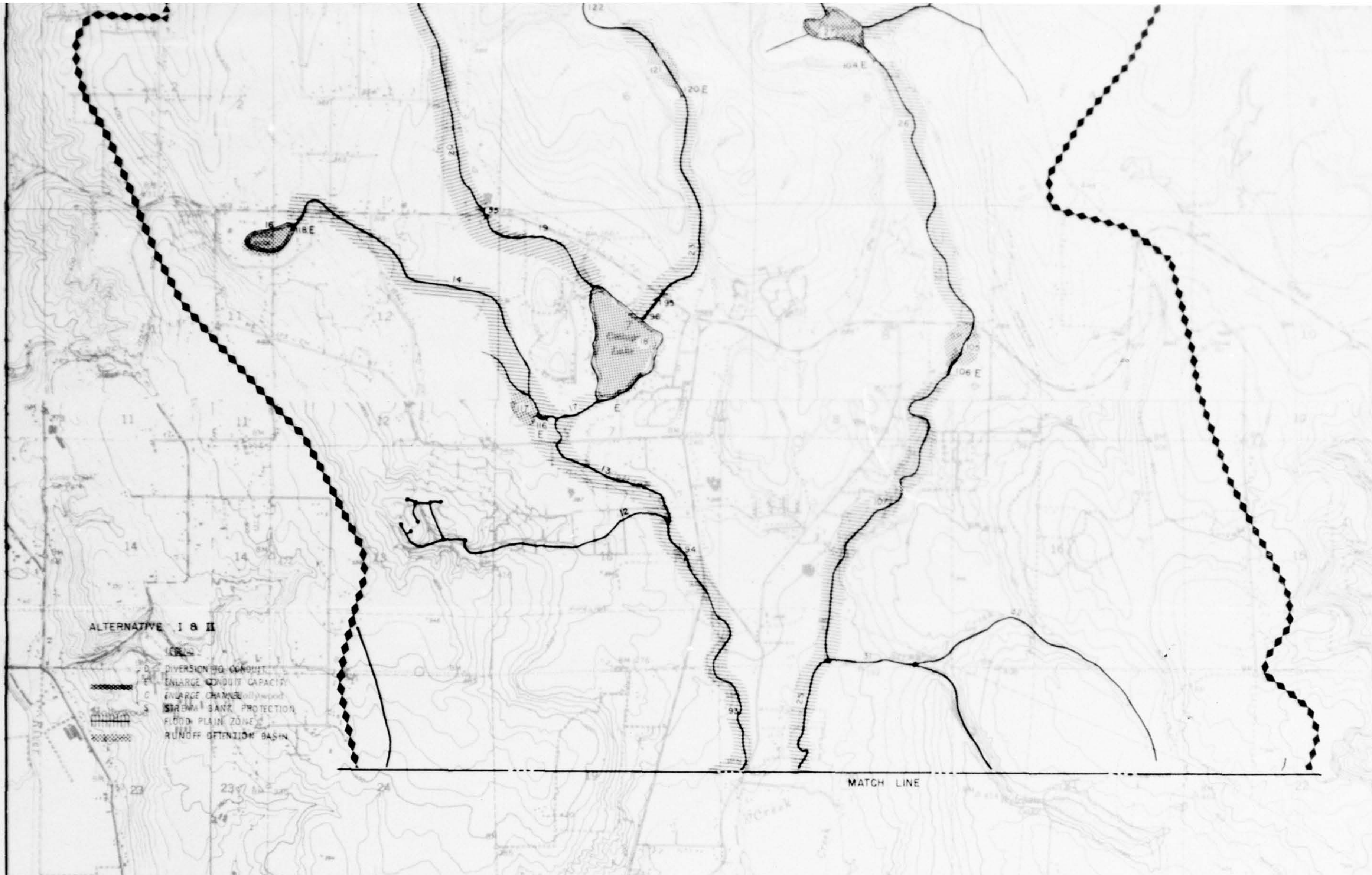
KRAMER, CHIN AND MAYO, INC.
WATER RESOURCES ENGINEERS, INC.
YODER, TROTTER, ORLOB & ASSOCIATES

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO. E-26-1-161 SHEET 2 OF 2

2


SNOHOMISH - KING COUNTY LINE



LEGEND

SUB-BASIN BOUNDARY
EXISTING CHANNEL
EXISTING CONDUIT
MANHOLE, INLET, OR JUNCTION
CHANNEL OR CONDUIT DESIG. 5
CITY LIMITS
COUNTY (METRO) BOUNDARY
LEVEE
CULVERT
HOLDING POND OR LAKE

N

MILES 1/2 1/4 0 1
FEET 1000 500 0 4000

NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

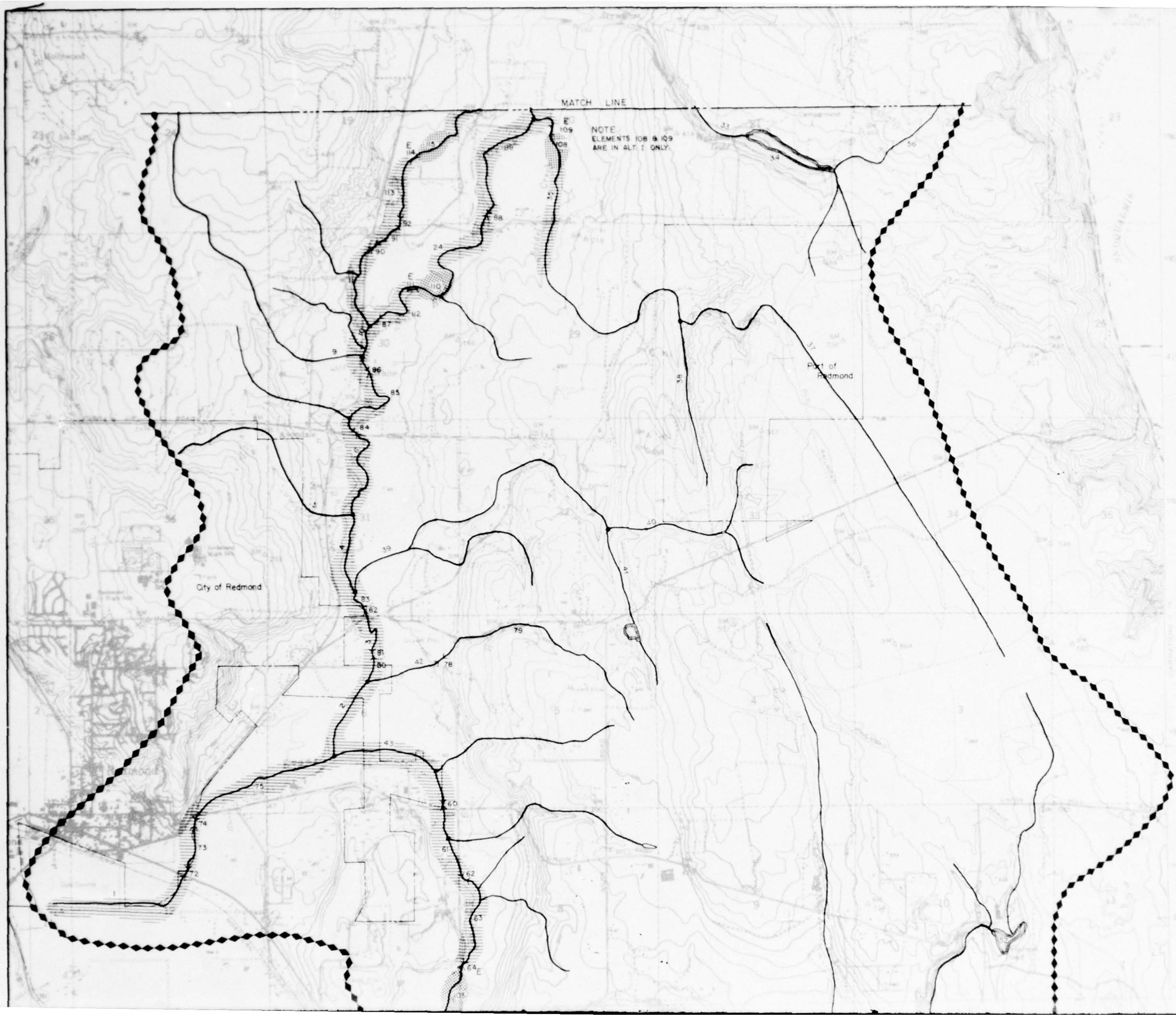
EVANS CREEK

PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

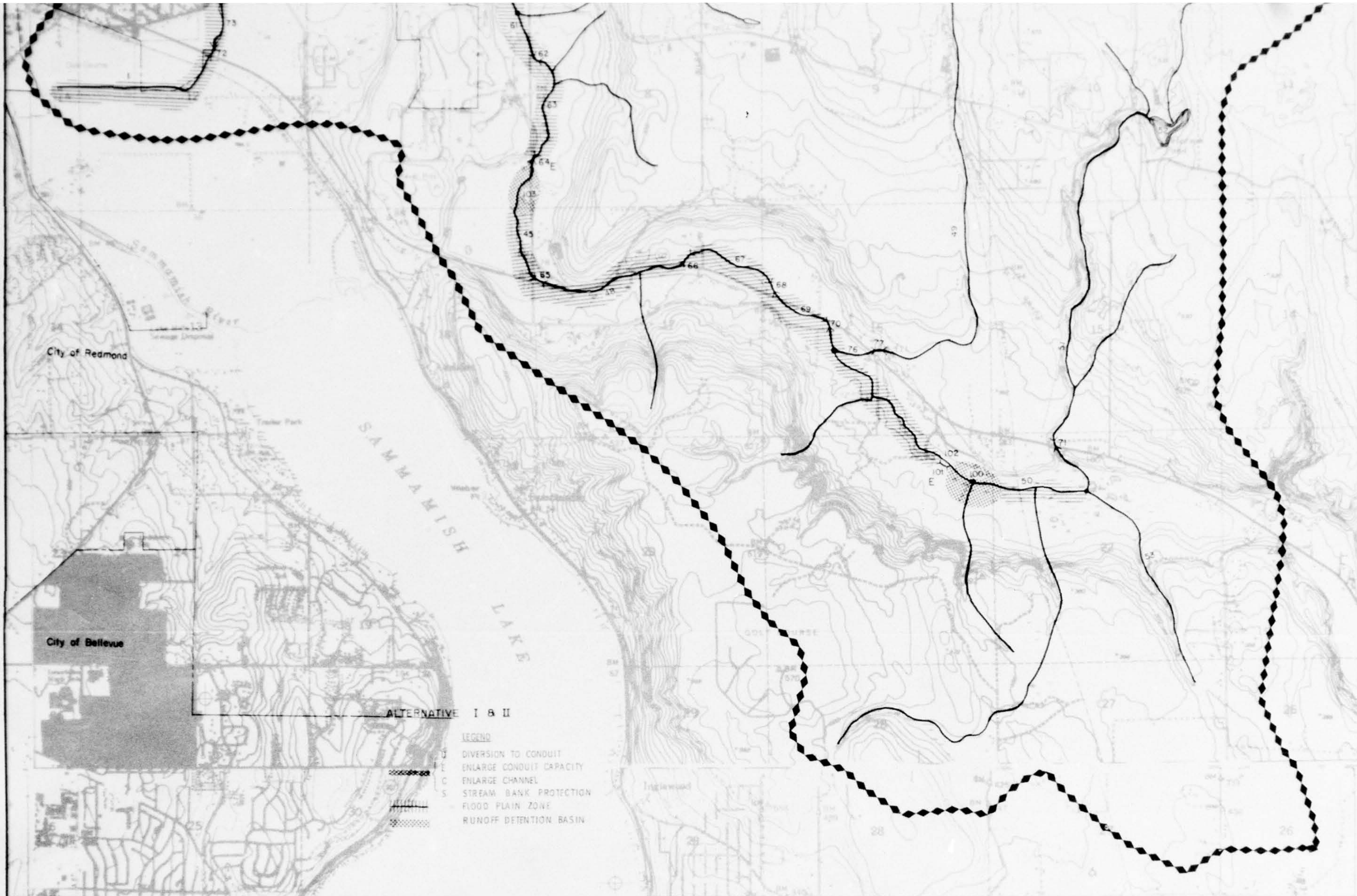
KRAMER, CHIN AND MAYO, INC
WATER RESOURCES ENGINEERS, INC
YODER, TROTTER, ORLOB & ASSOCIATES

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO. E-26-1-161 SHEET 1 D OF 2



MATCH LINE
NOTE:
ELEMENTS 108 & 109
ARE IN ALT. I ONLY.
Port of
Redmond
City of Redmond



LEGEND

SUB-BASIN BOUNDARY
EXISTING CHANNEL
EXISTING CONDUIT
MANHOLE, INLET, OR JUNCTION
CHANNEL OR CONDUIT DESIG — 5
CITY LIMITS
COUNTY (METRO) BOUNDARY
LEVEE

CULVERT
HOLDING POND OR LAKE

N

MILES: 1/2 — 1/4 — 0 — 1

FEET: 1000 — 500 — 0 — 4000

NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

EVANS CREEK

PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

KRAMER, CHIN AND MAYO, INC
WATER RESOURCES ENGINEERS, INC
YODER, TROTTER, ORLOB & ASSOCIATES

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO E-26-1-161 SHEET 2 bOF 2

REGIONAL SUB-BASIN C-6

BEAR CREEK

GENERAL DESCRIPTION

The Bear Creek Sub-Basin is located northeast of Lake Washington and north of Woodinville in the Cedar River Basin. The sub-basin is oriented in a north-south direction. It is bordered on the north by the Cedar River Basin-Snohomish River Divide, on the south by Woodinville, on the east by Clearview and Maltby and on the west by Bear Creek-North Creek Divide. State Route 202, Woodinville to Monroe, crosses Bear Creek in its lower reach and parallels the creek for approximately two miles. The sub-basin is approximately eight miles long and two miles wide.

The sub-basin is mostly wooded and largely in a natural condition. It has moderate to mildly sloping uplands that descend abruptly to Bear Creek in the upper half of the sub-basin. The lower portion has steep-sloped uplands that descend to a moderate valley flood plain.

The major stream is Bear Creek, approximately seven miles long, that begins at an elevation of 360 feet, and flows into the Sammamish River just west of Woodinville at approximately 20 feet elevation. There are a number of small tributaries to the creek, but there are no lakes of significance in the sub-basin.

Stream	Category	Drainage Area	Discharge
Bear Creek	III	17 sq. mi.	Sammamish River

Present development in the sub-basin is largely rural. The only significant suburban areas are Woodinville, which is almost at the mouth of Bear Creek, and Clearview at the northeast border of the sub-basin. The area adjacent to SR-202, between Woodinville and the Woodinville cutoff road, is developing into an industrial area. The remaining land is in forest or agricultural areas.

PERCENT OF SUB-BASIN AREA IN SPECIFIED LAND USE

Land Use	Existing (1970-72)	P.S.G.C. Land Use Projection Comprehensive	Corridor
	80% Rural	Urban	Urban
Single Family	20	40	30
Multiple Family		1	5
Commercial/ Services	1	2	3
Govt. and Educ.			1
Industrial	2	10	7
Parks/Dedicated Open Space	5	5	5
Agriculture	15	1	1
Airport, Railyards, Freeways, Highways			
Unused Land	57	41	48
Water			
Total	100	100	100
Total Impervious Area	10	30	20

Future development is projected to be concentrated in the sub-basin's lower portion between Woodinville and the Woodinville cutoff road. It probably will be a mixture of industrial areas adjacent to SR-202, commercial areas and surrounding single-family residential development.

Only two planning agencies are involved in the Bear Creek Sub-Basin. Snohomish County has jurisdiction for approximately 80 percent of the area and King County governs the remaining 20 percent. Woodinville is unincorporated at this time.

Public interest in Bear Creek has been high as exemplified by citizen reaction to several proposed developments in the area. The Woodinville

Community Action Council has been principal platform for community reaction.

NATURE OF EXISTING DRAINAGE SYSTEM

For planning purposes, Bear Creek can be considered to be in a natural condition. The creek has almost no flood plain in the upper part of the sub-basin due to the topography. The lower sub-basin has a small flood plain in the Woodinville area. No man-made storm drains are presently in the sub-basin except for culverts and drainage facilities constructed as part of highway development. Bear Creek supports a significant run of coho salmon.

DRAINAGE PROBLEMS

Major problems in the Bear Creek Sub-Basin, reported by local citizens as well as simulated with computer models, consist primarily of flooding along the main channel of Bear Creek together with incidences of flooding along two major tributaries in its mid-reaches. Associated with flooding are sedimentation and debris deposits. Fortunately, development directly along the main channel of Bear Creek has been limited to rural residential settings. so there has been little major damage and property loss. The severity of these problems undoubtedly will increase in future years as the area becomes more developed.

It is important to note that in the Bear Creek Sub-Basin the year 2000 Comprehensive Land Use Plan differs from the year 2000 Corridor Land Use Plan. Both plans project sizable increases in impervious area, with the year 2000 Comprehensive Plan showing a 30% coverage by impervious area and the 2000 Corridor Plan showing a 20% coverage by impervious areas. As seen from the preceding table, this compares to an existing impervious area within the sub-basin of only 10%. The Comprehensive Plan projects peak flows that are approximately double those anticipated under the Corridor Plan in most mid and upstream reaches. In the downstream reaches the flows projected by both land use plans are almost identical. Alternative drainage control plans, as described herein, have been developed for both land use plans.

If the runoff projected for future land use in the sub-basin is controlled by traditional techniques, it will produce a heavy impact on the stream. Residential development most likely would encroach upon the stream unless controlled. Streambank erosion and overbank flooding will occur and adjacent property owners would be forced to channelize and stabilize the creek adjacent to their property to reduce damage.

There are no sewers in the planning area at this time, which indicates the probability that coliform counts are or could become high. Runoff from the highway and the industrial-commercial areas probably also contributes to the water quality degradation.

BASIC ISSUES AND STATUS OF DRAINAGE PLANNING

The Snohomish County Planning Department, during its WASH-USE-1 project, investigated the storm-drainage needs of Bear Creek; however, during that study they did not address the impact upon the King County area. King County has not prepared plans for drainage in the Bear Creek Sub-Basin.

The opportunity for the two counties to jointly participate in land use and drainage planning in Bear Creek is excellent. The subbasin still is relatively undeveloped, therefore, a comprehensive plan can be developed and implemented without much difficulty. The eventual effect of such a plan would be to save Bear Creek as an urban stream.

Citizens' response to various drainage alternatives was not obtained for the Bear Creek Sub-Basin. Alternatives to alleviate drainage problems were developed by reviewing the alternatives preferred by citizens in neighboring watersheds.

During preparation of the drainage alternatives described below for Bear Creek Sub-Basin, officials from the Snohomish County Engineering and Planning Department were contacted and given an opportunity to review the various alternatives being considered.

ALTERNATIVE PLANS FOR PROPOSED DRAINAGE CONTROL

The existing drainage system of Bear Creek Sub-Basin, as described by local agencies, was evaluated by computer simulation applying the region's 10-year storm to the year 2000 land use. Drainage problems thus identified were analyzed and possible solutions provided in the development of alternative plans for drainage control as described below.

ALTERNATIVE PLAN I, 2000 COMPREHENSIVE LAND USE PLAN

General Concept

This concept is one that deals primarily with structural solutions to flooding and erosion problems. It consists primarily of two elements: holding ponds and a diversion pipeline.

Major Features

From computer model simulation, flooding began where Maltby Road crosses Bear Creek and progressed downstream. To alleviate this flooding, the first of four holding ponds was recommended for the area north of Maltby Road. Three other holding ponds also were used in this concept. They are at Grace, Turner Corner and just west of the Woodinville cutoff (Rt. 9), one mile north of Turner Corner. The locations of the holding ponds were selected so that they occurred in natural wetland depressions, were distant from major residential areas, and were located

near roads to facilitate construction, operation and maintenance.

For the excess flows that the holding ponds cannot contain, a diversion pipeline concept was used with the downstream channels. In this manner, flow exceeding the natural flow of a channel is diverted into a parallel pipeline. At that point where the natural channel can handle its own flow, plus that of the diverted flow, the diversion pipeline directs the flow back into the creek. This concept has the advantage of preserving the natural stream (i.e. it does not require enlargement of the stream channel or rip-rapping). Parallel pipelines would exist for a 6,000 foot portion of Bear Creek south of Maltby Road and a 5,000 foot portion of the creek south of the King-Snohomish County line.

Flood-plain zoning is used in the vicinity just north of Grace, north of the Maltby Road and at the mouth of Bear Creek.

Cost

The cost for this alternative is estimated to be $2,000,000.

ALTERNATIVE PLAN II, 2000 COMPREHENSIVE LAND-USE PLAN

General Concept

This concept is identical to Alternative Plan I, except land-use controls are added.

Major Features

The most significant feature of this alternative is that of land-use control. Essentially, development is limited in the sub-basins so that runoff from developed property is limited to approximately the same runoff that would occur under present conditions.

Presently, King County has a storm-drainage policy for land development that states, "...drainage plans shall provide storm water retention facilities so that peak discharge from the site will not be increased by more than 25% due to the proposed development."

Even with this policy, both holding ponds and a diversion pipeline will be required in the Bear Creek Sub-Basin.

Holding ponds, identified in Alternative Plan I, will be resized to obtain adequate capacity so that the diversion pipeline in some reaches of Bear Creek will not need to be as large as that of Alternative Plan I. The diversion pipeline will be used in the same locations as for Alternative Plan I.

Flood-plain zoning also would be necessary in the same areas as in Alternative Plan I.

Cost

Cost for this alternative is estimated to be $1,600,000.

ALTERNATIVE PLAN I, 2000 CORRIDOR LAND USE PLAN

General Concept

This concept is one that deals primarily with a structural solution to the flooding and erosion problems. It consists primarily of two elements: holding ponds and a diversion pipeline.

Major Features

From computer model simulation, flooding began on a tributary to Bear Creek southeast of Turner Corner and progressed downstream. To alleviate flooding, the first of two holding ponds was created in that vicinity. One other holding pond also was used in this concept north of Grace. It is important to note that the locations of the holding ponds were selected so that they occurred in natural wetland depressions, were distant from major residential areas, and were located near roads to facilitate easy construction, operation and maintenance.

For the excess flows that the holding ponds cannot contain, a diversion pipeline concept was used with the downstream channels. In this manner, flow exceeding the natural flow of a channel is diverted into a parallel pipeline that conveys the flow until the creek has sufficient capacity to accommodate its present flow plus that of the diverted flow. At this point, the diversion pipeline directs the flow back into the creek. This concept has the advantage of preserving the natural stream (i.e. it does not require enlarging or rip-rapping). Parallel pipelines would exist for approximately 5,000 feet south of Grace.

Flood-plain zoning is designated for the mouth of Bear Creek and the area by the gravel pit adjacent to Rt. 9.

Cost

The cost for this alternative is estimated to be $1,100,000.

ALTERNATIVE PLAN II, 2000 CORRIDOR LAND USE PLAN

General Concept

This concept is identical to Corridor Land Use Alternative Plan I, except for one major addition, which is runoff control.

Major Features

The most significant feature of this alternative is that of runoff control. Essentially, development in the area is controlled so that runoff from developed property is limited to approximately the same runoff that would occur under present (undeveloped) conditions.

Presently, King County has a storm drainage policy for land development that states, "...drainage plans shall provide storm water retention facilities so that peak discharge from the site will not be increased by more than 25% due to the proposed development."

Even with this policy, both holding ponds and a diversion pipeline will be required in the Bear Creek Sub-Basin.

Holding ponds identified for Corridor Land Use Alternative Plan I will be resized to generate adequate capacity so that the diversion pipeline in some reaches of Bear Creek will not need to be as large as that of Corridor Land Use Alternative Plan I. The diversion pipeline will be used in the stream section as with Corridor Land Use Alternative Plan I.

Flood-plain zoning is designated for the same areas identified in Corridor Land Use Alternative Plan I.

Cost

Cost for this alternative is estimated to be $700,000.

PEAK FLOW COMPARISONS

The following table indicates 10-year peak flows with existing facilities and with alternative drainage management solutions for the year 2000. The peak flows are given for portions of the creek as indicated, as well as at the point of discharge into the Sammamish River.

COMPARISON OF 10-YEAR PEAK FLOWS
(Cubic Feet Per Second)

	Comprehensive Land Use			Corridor Land Use	
Location	Existing Facilities	Alternative Plan I	Alternative Plan II	Alternative Plan I	Alternative Plan II
N. of Maltby Road	200	210	210	60	60
1/2 mile south of Turner Corner	160	260	260	140	110
Canyon Park Rd.	260	350	300	350	150
At Grace	380	720	400	750	340
1/2 mile south of Grace	200	490	370	540	370
Mouth at Sammamish River	250	480	360	550	360

ENVIRONMENTAL ASSESSMENT OF ALTERNATIVE PLANS

As part of the process of developing system proposals for the various regional sub-basins in the RIBCO Study, field inspections were made to determine the applicability of the suggested alternatives for each sub-basin. Inspections were made based on the alternative evaluation procedure which identified 34 unique criteria under the general categories of 1) Effectiveness, 2) Human Values, 3) Environmental Factors, 4) Implementation, and 5) Resource Requirements. In addition, projected land use was reviewed for compatibility with the proposed system. As applied to Bear Creek, the overall evaluation rating total for Alternative Plan I, under the Comprehensive Land Use Plan, was a plus 10 on a scale ranging from positive 108 to negative 108. The overall rating for Alternative Plan II, under the Comprehensive Land Use Plan, which employed runoff control, was a plus 23. Under the Corridor Plan, Alternative Plan I received a rating of plus 19 and Alternative Plan II received a rating of plus 32.

Both alternatives under the Comprehensive Land Use Plan require more extensive use of diversion pipeline than the systems necessary to accommodate land use under the two corridor alternative plans. In all alternatives presented, the stream is allowed to remain in its natural condition, aided in some cases by the diversion channels or holding ponds. All alternatives presented provide approximately the same human values and all are considered equally difficult to implement. Resource requirements are relatively minor for all alternatives and all alternatives are judged to be relatively equal in effectiveness of handling storm drainage. The major difference in the rating totals occurred in the impact of the various alternatives on environmental factors. The combination of land use location and minimal man-made drainage facilities, resulted in a relatively high score for Alternative Plan II under the Corridor Land Use Plan.

As the Bear Creek Sub-Basin is undeveloped at this time, implementation of any of the alternatives within the immediate future would allow the preservation of the stream as provided for in the various alternatives. All systems rely upon the preservation and use of wetland areas for storage. This element of all alternatives is considered critical and would require early action if used as part of the solution to drainage management in the Bear Creek Sub-Basin.

CONCLUSION

The Corridor Land Use Plan requires the least need for drainage facilities of the two land use plans used. Alternative Plan II for the Corridor Land Use Plan is judged to be the most effective in preserving the natural stream as well as for controlling runoff under most conditions. This alternative accomplishes recharge of groundwater and should allow for adequate low flows during low precipitation periods, thus assuring the continuation of aquatic life in the stream. Alternative

Plan II does require fairly immediate action because of its reliance upon runoff controls and acquisition of easements for use of existing wetlands within the sub-basin.

Because of the extent of the sub-basin in Snohomish County jurisdiction, that agency should be designated for the lead role in drainage management of Bear Creek.

RUNOFF QUALITY SUMMARY
BEAR CREEK

BASED UPON A 10-YEAR STORM PRECEDED BY 15 DAYS WITH LITTLE OR NO RAINFALL#

LOCATION	ALTERNATIVE PLAN	PEAK FLOW (cfs)	CONCENTRATION AT PEAK FLOW*				
			BOD	TOTAL COLIFORM	NH_3	$NO_2 + NO_3$	PO_4
Mouth of Creek	2000 Comprehensive Land Use						
	I	480	11	5.8×10^4	.4	1.3	.1
	II	360	11	6.1×10^4	.4	1.3	.1
	2000 Corridor Land Use						
	I	550	19	1.8×10^5	.7	1.7	.2
	II	360	22	2.3×10^5	.8	1.9	.2

Less than a total of 0.5 inches of rainfall in any one day.
* Concentrations in mg/liter except total coliform which is in MPN/100 ml.

EVALUATION MATRIX

BEAR CREEK

ALTERNATIVES	EFFECTIVENESS SUB TOTAL	Use of existing facilities (1)	System reliability (4)	System maintainability (3)	System flexibility (2)	Flood damage reduction (4)	Consequences of overcharge (4)	Erosion and sedimentation control (4)	Cost/benefits ranking (2)
I COMP.	+3								
II COMP.	+7								
I CORR.	+5								
II CORR.	+9								

ALTERNATIVES	HUMAN VALUES SUB TOTAL	Urban quality (aesthetics) (4)	Effect on land use (2)	Displacement of people (2)	Educational value (1)	Community cohesion (3)	Multiple use potential (3)	Public health and safety (4)
I COMP.	+4							
II COMP.	+5							
I CORR.	+4							
II CORR.	+5							

ALTERNATIVES	ENVIRONMENTAL FACTORS SUB TOTAL	High flow conditions (4)	Alteration of natural system (4)	Effects on groundwater (4)	Low flow conditions (4)	Water quality (4)	Construction disruption (2)	Effects on wildlife (4)	Effects on aquatic life (4)	Effects on vegetation (4)
I COMP.	+6									
II COMP.	+14									
I CORR.	+12									
II CORR.	+20									

ALTERNATIVES	IMPLEMENTATION SUB TOTAL	Legislative requirements (4)	Jurisdictional (4)	Land acquisition (2)	Public acceptance (4)	Financing (4)	Effects of no action (3)
I COMP.	-4						
II COMP.	-4						
I CORR.	-4						
II CORR.	-4						

ALTERNATIVES	RESOURCE REQUIREMENTS SUB TOTAL	Energy (3)	Materials (3)	Land (2)	Capital (2)	RATING TOTAL
I COMP.	+1					+10
II COMP.	+1					+23
I CORR.	+2					+19
II CORR.	+2					+32

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative I Sub Basin Bear Creek - Comprehensive Plan

ELEMENT NUMBER	EXISTING FACILITIES TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	PROPOSED FACILITIES TYPE		ESTIMATED CAPITAL COST
47	None					Holding Pond	98 AF 14 acres	$283,000
48	None					Holding Pond	31 AF 12 acres	$122,000
49	None					Holding Pond	7 AF 9 acres	$86,000
50	None					Holding Pond	3 AF 3 acres	$50,000
2	Pipe	8'	30'			Parallel Pipe	96"	$6,000
4	Pipe	8'	30'			Parallel Pipe	96"	$6,000
9	Channel	10'	5,500'	1:1	3'	Diversion Pipe	66"	$743,000
45	None					Pipe	48" 100'	$9,000
17	Channel	11'	3,100'	1:1	3'	Diversion Pipe	36"	$205,000
43	None					Pipe	24" 100'	$4,000
21	Channel	10'	4,500'	1:1	3'	Diversion Pipe	48"	$419,000
41	None					Pipe	27" 100'	$5,000
40	None					Pipe	18" 100'	$3,000
9	None					Inlet/ Outlet	For 66" diversion pipe	$11,000
17	None					Inlet/ Outlet	For 36" diversion pipe	$6,000
21	None					Inlet/ Outlet	For 48" diversion pipe	$8,000

The Estimated Capital Cost for each element includes Contractor profit, engineering, legal and contingencies. In addition, land purchase and severance costs are included where land is required. All costs are based upon June 1973 prices.

Total Estimated Capital Cost: $1,966,000
Round To: $2,000,000

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative I Sub-Basin Bear Creek - Corridor Plan

	EXISTING FACILITIES					PROPOSED FACILITIES		
ELEMENT NUMBER	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
47	None					Holding Pond	71 AF 14 acres	$209,000
48	None					Holding Pond	6 AF 6 acres	$67,000
2	Pipe	8'	30'			Parallel Pipe	96"	$6,000
4	Pipe	8'	30'			Parallel Pipe	96"	$6,000
9	Channel	10'	5,500'	1:1	3'	Diversion Pipe	72"	$820,000
45	None					Pipe	48" 100'	$9,000
43	None					Pipe	24" 100'	$4,000
9	None					Inlet/ Outlet	For 72" diversion pipe	$11,000

The Estimated Capital Cost for each element includes Contractor profit, engineering, legal and contingencies. In addition, land purchase and severance costs are included where land is required. All costs are based upon June 1973 prices.

Total Estimated Capital Cost: $1,132,000

Round To: $1,100,000

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative II Sub-Basin Bear Creek - Comprehensive Plan

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
47	None					Holding Pond	55 AF 14 acres	$183,000
48	None					Holding Pond	12 AF 12 acres	$98,000
49	None					Holding Pond	7 AF 9 acres	$86,000
50	None					Holding Pond	3 AF 3 acres	$50,000
2	Pipe	8'	30'			Parallel Pipe	96"	$6,000
4	Pipe	8'	30'			Parallel Pipe	96"	$6,000
9	Channel	10'	5,500'	1:1	3'	Diversion Pipe	48" for diversion	$506,000
45	None					Pipe	48" 100'	$9,000
17	Channel	~11'	3,100'	1:1	3'	Diversion Pipe	36" for diversion	$205,000
43	None					Pipe	24" 100'	$4,000
21	Channel	10'	4,500'	1:1	3'	Diversion Pipe	48" for diversion	$419,000
41	None					Pipe	27" 100'	$5,000
40	None					Pipe	18" 100'	$3,000
9	None					Inlet/ Outlet	For 48" diversion pipe	$8,000
17	None					Inlet/ Outlet	For 36" diversion pipe	$6,000
21	None					Inlet/ Outlet	For 48" diversion pipe	$8,000

The Estimated Capital Cost for each element includes Contractor profit, engineering, legal and contingencies. In addition, land purchase and severance costs are included where land is required. All costs are based upon June 1973 prices.

Total Estimated Capital Cost: $1,602,000
Round To: $1,600,000

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

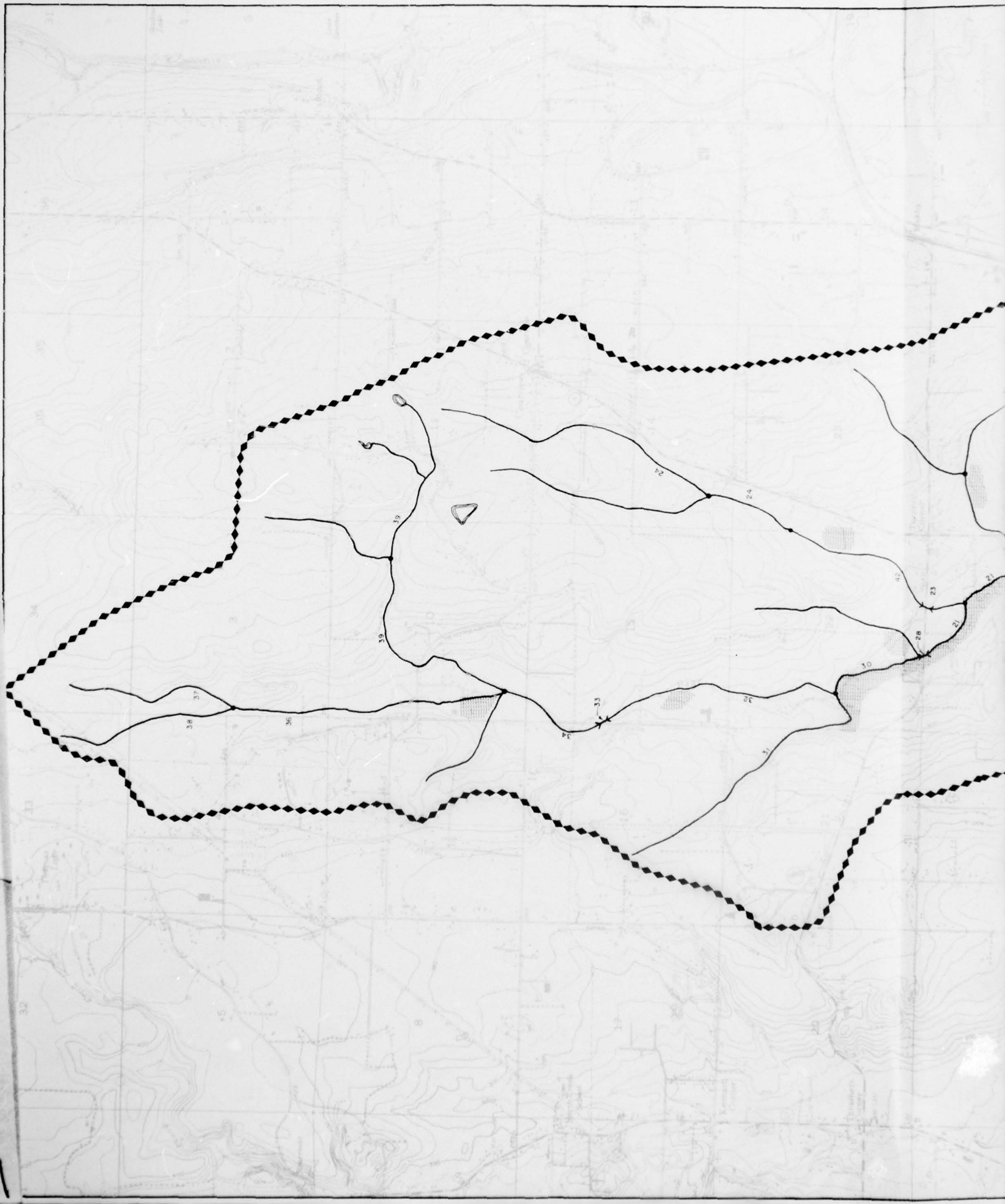
Alternative II Sub Basin Bear Creek - Corridor Plan

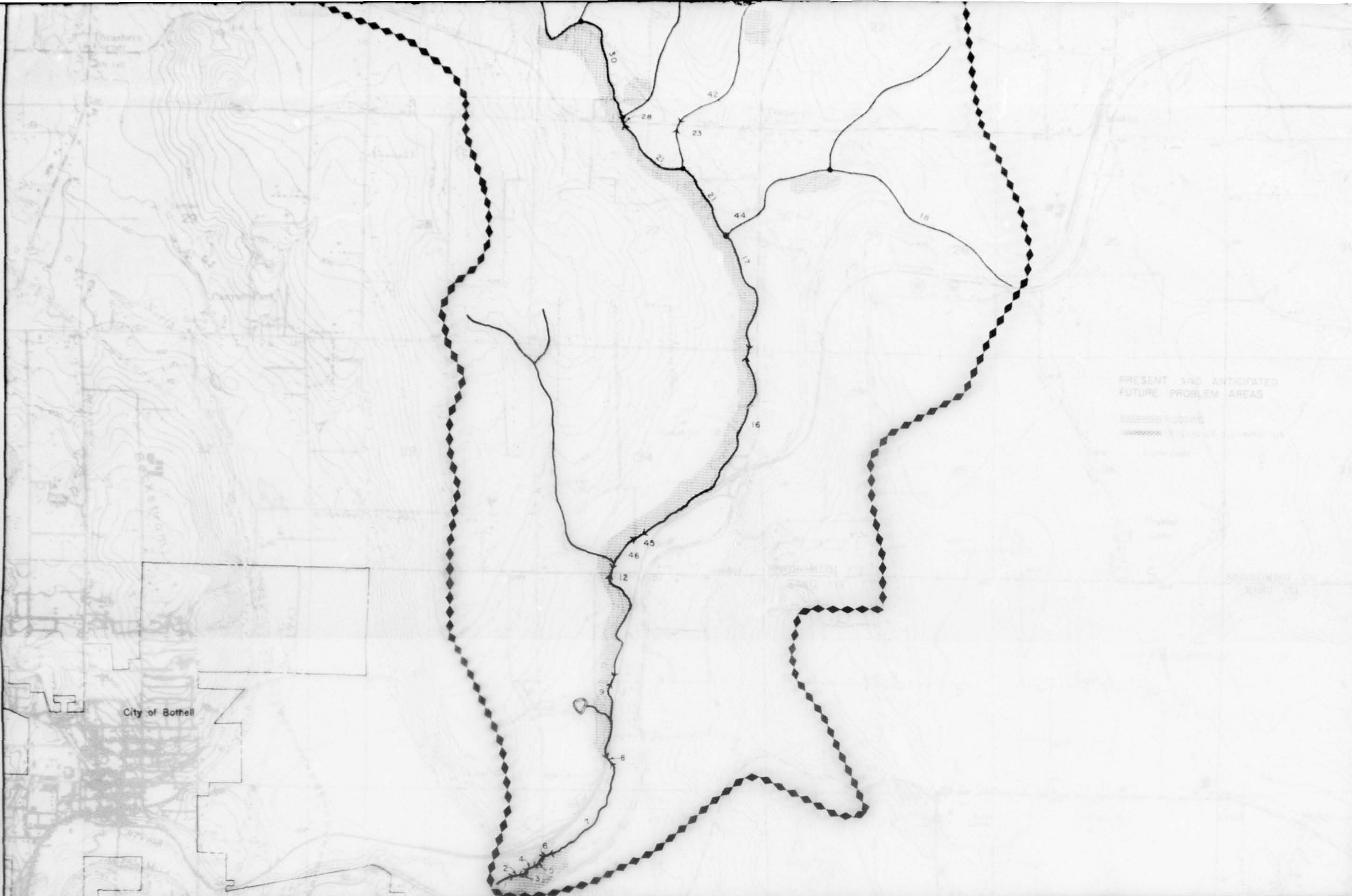
ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
47	None					Holding Pond	40 AF 14 acres	$152,000
48	None					Holding Pond	3 AF 3 acres	$49,000
2	Pipe	8'	30'			Parallel Pipe	96"	$6,000
4	Pipe	8'	30'			Parallel Pipe	96"	$6,000
9	Channel	10'	5,500'	1:1	3'	Diversion Pipe	48"	$512,000
45	None					Pipe	48" 100'	$9,000
43	None					Pipe	24" 100'	$4,000
9	None					Inlet/ Outlet	For 48" diversion pipe	$8,000

The Estimated Capital Cost for each element includes Contractor profit, engineering, legal and contingencies. In addition, land purchase and severance costs are included where land is required. All costs are based upon June 1973 prices.

Total Estimated Capital Cost: $746,000

Round To: $700,000





LEGEND

SUB-BASIN BOUNDARY
EXISTING CHANNEL
EXISTING CONDUIT
MANHOLE, INLET, OR JUNCTION
CHANNEL OR CONDUIT DESIG
CITY LIMITS
COUNTY (METRO) BOUNDARY
LEVEE

CULVERT
HOLDING POND OR LAKE

N

MILES 1/2 1/4 0 1

FEET 1000 500 0 4000

NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

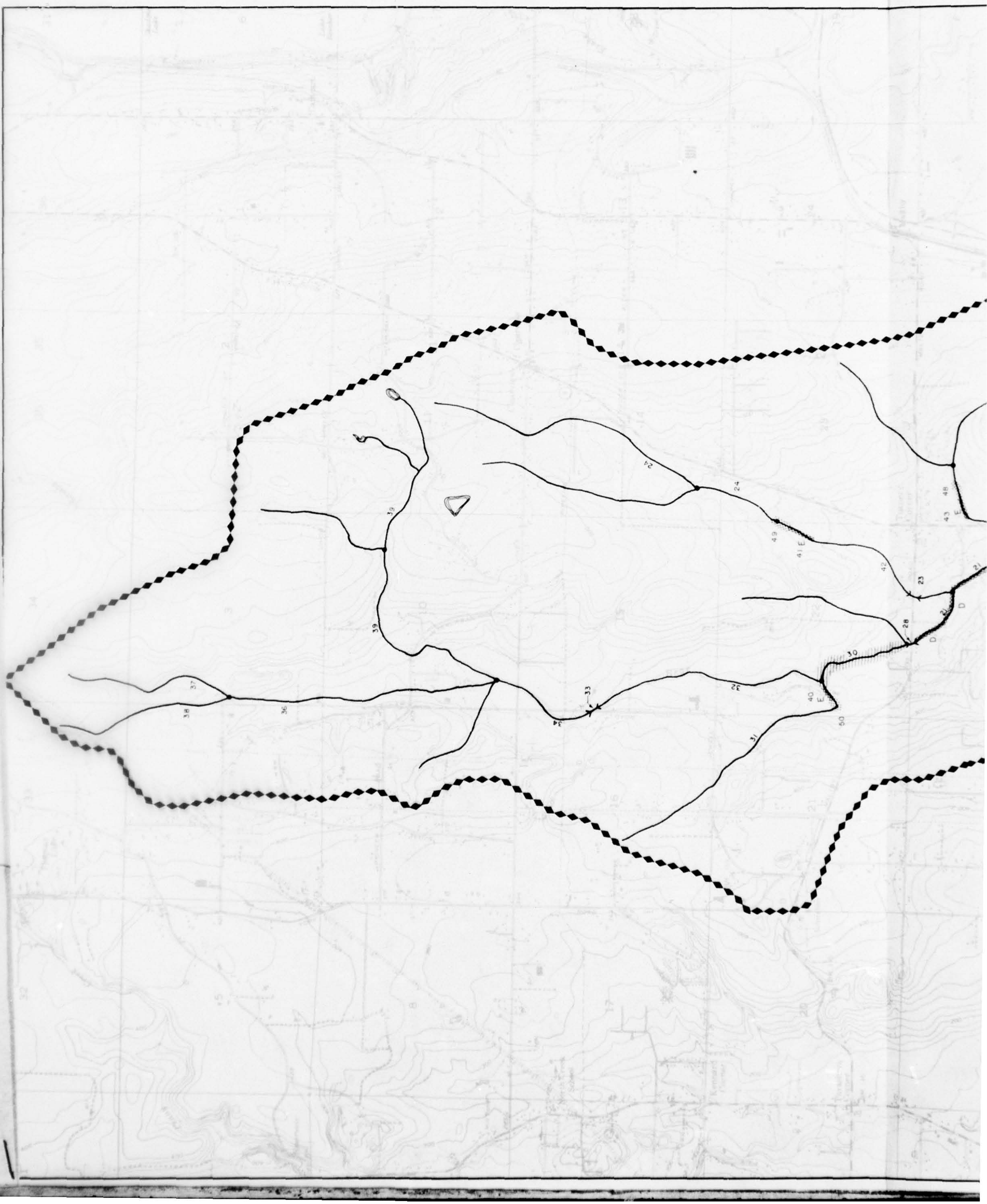
BEAR CREEK

PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

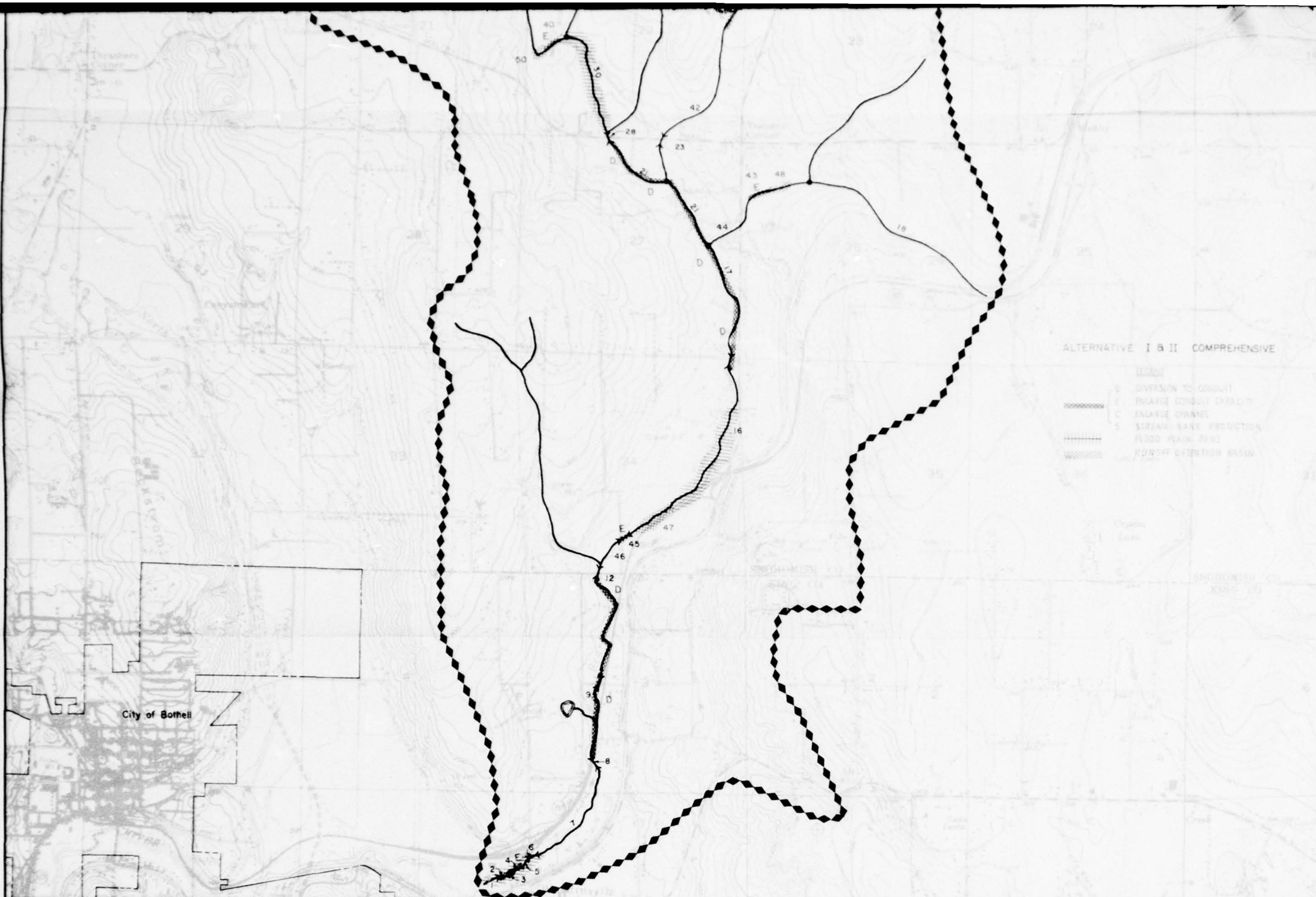
KRAMER, CHIN AND MAYO, INC
WATER RESOURCES ENGINEERS, INC
YODER, TROTTER, ORLOB & ASSOCIATES

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO. E-26-1-161 SHEET 1 OF 1



37
38
36
39
39
24
24
49
41 E
42
23
28
30
40 E
50
31
32
33
34
48
43 E
21
D



LEGEND

SUB-BASIN BOUNDARY
EXISTING CHANNEL
EXISTING CONDUIT
MANHOLE, INLET, OR JUNCTION
CHANNEL OR CONDUIT DESIG. 5
CITY LIMITS
COUNTY (METRO) BOUNDARY
LEVEE

CULVERT
HOLDING POND OR LAKE

1/2 1/4 0 1 MILES
1000 500 0 4000 FEET

NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

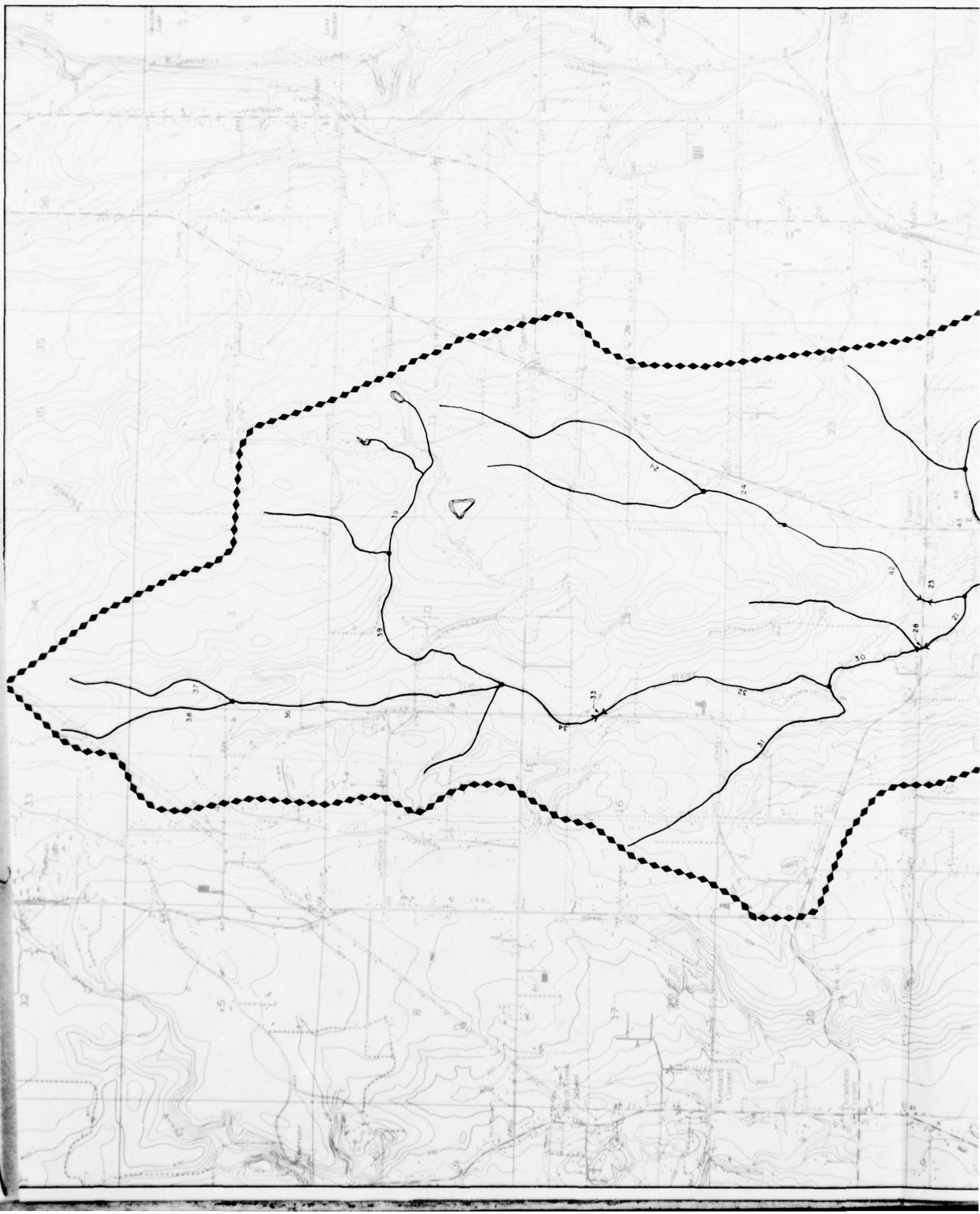
BEAR CREEK

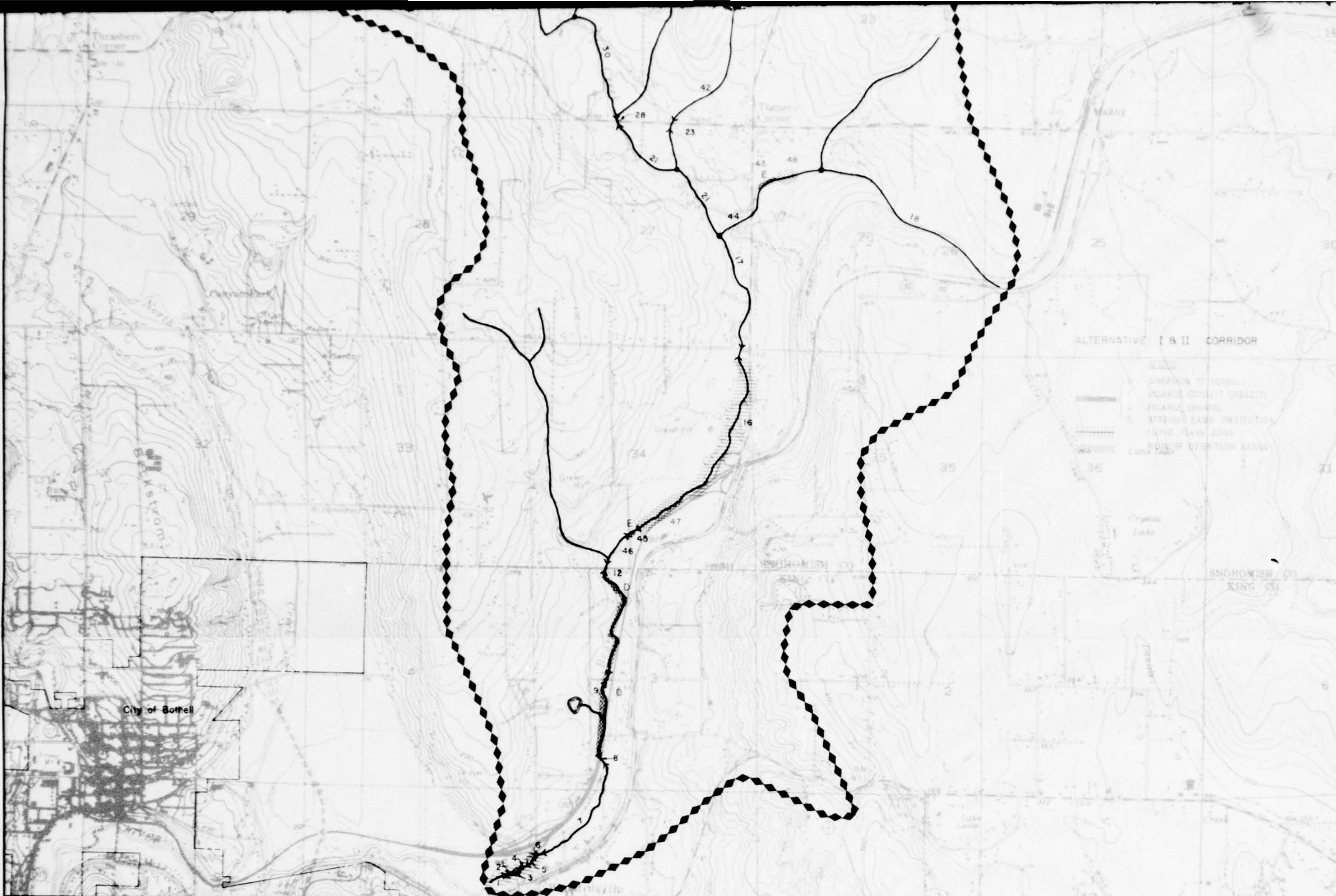
PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

KRAMER, CHIN AND MAYO, INC.
WATER RESOURCES ENGINEERS, INC.
YODER, TROTTER, ORLOB & ASSOCIATES

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO. E-26-1-161 SHEET 1b OF 1





LEGEND

SUB-BASIN BOUNDARY
EXISTING CHANNEL
EXISTING CONDUIT
MANHOLE, INLET, OR JUNCTION
CHANNEL OR CONDUIT DESIG. 5
CITY LIMITS
COUNTY (METRO) BOUNDARY
LEVEE

CULVERT
HOLDING POND OR LAKE

N

1/2 1/4 0 1 MILES

1000 500 0 4000 FEET

NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

BEAR CREEK

PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

KRAMER, CHIN AND MAYO, INC.
WATER RESOURCES ENGINEERS, INC.
YODER, TROTTER, ORLOB & ASSOCIATES

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO. E-26-1-161 SHEET 1C OF 1

2

REGIONAL SUB-BASIN C-7

NORTH CREEK

GENERAL DESCRIPTION

The North Creek Sub-Basin is in the northern portion of the Cedar River basin that drains to Lake Washington. The sub-basin runs generally north-south between the City of Everett and the City of Bothell and east of Interstate Highway 405.

The sub-basin is approximately 11 miles long and two and a half miles wide and is drained by two major streams; North Creek which runs the length of the sub-basin and Penny Creek which is approximately four miles long. The headwaters of Penny Creek is Silver Lake. The headwaters of North Creek are in Everett and the creek runs south until it joins the Sammamish River near the junction of I-405 and SR-522 at Bothell. Three Lakes (Silver, Ruggs, and Thomas) are located along Penny Creek. Penny Creek is dammed just above its junction with North Creek, but the structure has only minor impact upon the creek flow. Penny Creek joins North Creek in the upper third of the watershed.

Stream	Category	Drainage Area	Discharge
North Creek	II	29 sq. mi.	Sammamish River
Penny Creek	III	5.4 sq. mi.	North Creek

The sub-basin headwater elevation is approximately 520 feet dropping to 17 feet at the confluence with the Sammamish River. The terrain in the upper sub-basin is gently sloping uplands with a narrow valley plain. In the lower portion of the sub-basin, the uplands shorten and steepen and the valley plain widens to almost three-quarters of a mile at the confluence.

Present land use consists largely of rural/agricultural and forested areas except for low-density residential development at the northern boundary of the sub-basin around I-5 and Silver Lake. The sub-basin is in a predominately undeveloped state at this time.

PERCENT OF SUB-BASIN AREA IN SPECIFIED LAND USE

Land Use	Existing (1970-72)	P.S.G.C. Land Use Projection Comprehensive	P.S.G.C. Land Use Projection Corridor
Single Family	45	60	60
Multiple Family		5	5
Commercial/ Services		5	1
Govt. and Educ.	1	1	1
Industrial			5
Parks/Dedicated Open Space	10	5	5
Agriculture	5	21	
Airports, Railyards, Freeways, Highways	2	2	2
Unused Land	36		20
Water	1	1	1
Total	100	100	100
Total Impervious Area	10	30	30

Four agencies have drainage responsibilities within the North Creek Sub-Basin. These jurisdictions in order of land area are: Snohomish County 80%, City of Everett 10%, City of Bothell 5%, and King County 5%.

None of these agencies has developed a storm-drainage plan for the sub-basin and no coordinated sub-basin planning has been attempted.

NATURE OF EXISTING DRAINAGE SYSTEM

The North Creek drainage system is a series of natural lakes connected by natural stream channels. In the area of Thomas Lake, the stream meanders due to swampy peat soils. Here the channel was enlarged and modified by Snohomish County to provide better runoff capacity. North Creek is in a natural condition except for the last 4,000 feet above the Sammamish River confluence which has been dredged and realigned.

North Creek has a significant salmon run with the average number of spawners estimated to be 3,000 fish per year. This represents a significant production for the creek and it is considered an important resource by the Department of Fisheries. Only minor man-made drainage facilities are present in the sub-basin.

DRAINAGE PROBLEMS

Present problems have been identified by the Snohomish County Engineering Department; water ponding adjacent to the creek and some actual flooding in the downstream portion of North Creek. Because of compatible land use along the creek, such as agriculture and open space, as well as a small population, relatively few drainage problems have been reported.

The water quality of the streams is affected by high temperatures in summer and high coliform counts that result from septic-tank seepage. Erosion and stream sedimentation has occurred in some areas but it is not considered significant at this time.

If development occurs as predicted, and if no controls are exerted over increased runoff, future problems in the sub-basin will be increased overbank flooding and a significant increase in streambank erosion and sedimentation. Significant damage also will occur in the downstream industrially-zoned area of North Creek in the Corridor Plan. A major future problem will be increased flooding within the City of Bothell and in King County as further development occurs in the upper watershed. Salmon production will decline as development takes place, unless runoff can be controlled.

The total impervious area in this sub-basin under either the year 2000 Comprehensive or Corridor Land Use Plan, is projected to increase from existing 10% level to approximately 30%.

Future runoff, as projected in the 2000 Comprehensive Land-Use Plan, would intensify existing flooding problems and would create additional ones as well. Almost 75% of the length of North Creek will experience overbank flooding. Ruggs Lake and Thomas Lake area experience fluctuation in lake levels causing possible damage to lake-side residences and recreational facilities. The predicted velocities associated with these overbank flooding problems indicate the possibility of bank erosion and the need for protection.

BASIC ISSUES AND STATUS OF DRAINAGE PLANNING

No comprehensive planning has been completed by any agency within the sub-basin. Snohomish County has completed a planning study that involves generalized urban drainage planning (WASH-USE 1)but the study did not consider the King County portion of the sub-basin.

The City of Bothell has completed a Storm Drainage Master Plan, but it does not include the North Creek section of the City.

The City of Everett and King County have not undertaken significant planning in their areas, and no future drainage planning for the sub-basin is presently known to be under consideration.

Snohomish County, the agent which controls the largest area within the watershed, has a general drainage policy for preservation of the natural drainage system, that limits runoff to near natural rates, especially from industrial and commercial areas and prohibits all intensive land development within the 100-year flood plain. These general policies are compatible with the philosophy for maintaining a natural stream environment that has been expressed by the public during the RIBCO Study. King County, through its Environmental Development Commission, has also set goals of maintaining the natural environment of the existing stream system.

Staff members from the Snohomish County Engineering and Planning Department and the King County Public Works Department, Hydraulics Division, have reviewed the initial alternative plans for drainage developed by this RIBCO Study for the North Creek Sub-Basin.

ALTERNATIVE PLANS FOR PROPOSED DRAINAGE CONTROL

The existing drainage system of the North Creek Sub-Basin, as described by local agencies, was evaluated by computer simulation applying the region's 10-year storm to the year 2000 land use. Drainage problems thus identified were analyzed and possible solutions provided in the development of alternative plans that will relieve all future drainage problems and will not create any new problems.

ALTERNATIVE PLAN I

General Concept

The general concept of Alternative Plan I involves the channelization of North Creek to control overbank flooding. Streambank protection would be provided where required. Bridges and culverts would be enlarged to pass flows without restriction.

Major Features

The major features consist of the enlarging of most culverts beneath roads in the upper sub-basin and almost continuous channelization from below the confluence of Penny Creek and North Creek to North Creek's mouth at the Sammamish River. Streambank protection is also required to prevent erosion from the increased stream velocities.

Cost.

The cost for Alternative Plan I is estimated to be $9,100,000.

ALTERNATIVE PLAN II

General Concept

Alternative Plan II consists of on-site runoff control in future developing areas within the watershed, provision of storage along North and Penny Creeks in lakes and holding ponds, and some flood-plain zoning. Streambank protection will be provided where required.

Major Features

Three major features make up Alternative Plan II. The first, runoff control, is applied throughout the sub-basin. Runoff control consists of limiting runoff from any future development within the sub-basin to a maximum runoff increase of 25% above existing conditions. This criteria will reduce runoff from future developing areas to near natural conditions.

The second major feature is the construction of holding ponds to attenuate downstream flows at three locations. The ponds are planned at 183rd St., S.E., south of Filbert Road and north of Vine Street on a North Creek tributary. Silver Lake, Ruggs Lake and Thomas Lake could also serve to store water and lower downstream flows on Penny Creek. Finally, flood-plain zoning would be used to restrict activities in the lower reaches that will experience overbank flooding.

On-site runoff control for all new development within the watershed will be required for this alternative to be feasible. Without consistent applications of this policy, increased runoff rates could exceed the planned channel capacities. The holding ponds have been sized to store greater volumes of water than is predicted for the 10-year storm. If runoff is not controlled within the sub-basin, the pond's capacity could be exceeded by lower intensity storms causing greater flows and possible damage. The holding-pond sites presently are in undeveloped areas and could be engineered to provide secondary uses during dry-weather periods.

Flood-plain zoning of the creek's lower reaches will alleviate the need to enlarge downstream low-capacity channels. These channels presently run through undeveloped property and such zoning is feasible.

Streambank protection for the creek has been included as a cost in this alternative. Field inspection and further analysis could prove that this cost is not warranted, thereby further reducing this alternative's total cost.

Cost

The cost for Alternative Plan II is estimated to be $2,900,000.

PEAK FLOW COMPARISONS

The following table indicates existing and probable future stream flows under the two alternative drainage plans.

COMPARISON OF 10-YEAR PEAK FLOWS
(Cubic Feet Per Second)

Location	Facilities*	Alternative Plan I	Alternative Plan II
North Creek below confluence with Penny Creek	240	950	300
Penny Creek's Mouth	190	425	40
North Creek above Thrasher's Corner	220	975	260
North Creek USGS Gage	650	1400	520
Mouth of North Creek	450	1500	525

*NOTE: Flows reduced by upstream flooding

ENVIRONMENTAL ASSESSMENT OF ALTERNATIVE PLANS

Field inspections were made of the suggested alternative plans for this sub-basin. This process was followed throughout the RIBCO Study in developing alternative plans for the various regional sub-basins. The inspections were based on the alternative evaluation procedure which identified 34 unique criteria grouped in general categories as follows: 1) Effectiveness, 2) Human Values, 3) Environmental Factors, 4) Implementation, and 5) Resource Requirements. The various structural solutions were checked against the appropriate criteria, and the various non-structural solutions were reviewed for their relationship to existing and probable future developments. The criteria rating total for Alternative Plan I, which employs streambank protection, channelization and diversion was a minus 40 on a scale ranging from a positive total of 108 to a negative total of 108. The criteria rating total for Alternative Plan II, which employs streambank protection and flood-plain zoning, as well as storage and runoff control, was a plus 6.

Alternative Plan II is judged to be superior to Alternative Plan I in effectiveness for controlling storm water runoff. The consequences of overcharge are considered to be less and the ability to further alter the system is believed to be better. Both alternative plans are judged to be relatively equal in terms of human values, although neither one

received a strong positive rating in this category. The amount of flood-plain zoning in Alternative Plan II is not believed to be enough to provide a high level of multiple-use potential nor would it significantly increase community cohesion. Both alternative plans would have questionable environmental effects, the more significant being associated with Alternative Plan I, which provides no protection for low-flow conditions and does little to enhance water quality. It would require extensive construction disruption and potential disturbance of wildlife, aquatic life and vegetation. Alternative Plan II does promote water quality and assures satisfactory low-flow conditions. If streambank protection suggested for this alternative is not carried out to the extent shown, this alternative plan could have beneficial effects upon wildlife, aquatic life and vegetation. Preservation of fisheries potentials must be an important part of drainage control for North Creek because of the existing salmon runs. Both alternative plans are considered equally difficult to implement because of the numerous jurisdictions involved. Alternative Plan II is considered to have fewer resource requirements than Alternative Plan I and it received a positive rating because some portions of the system have a use beyond the needs of drainage.

A critical element in Alternative Plan II is the proposal to use runoff control and storage in the upper basin. This treatment, if it is to be part of the chosen alternative, should be implemented as an early organized effort of the involved agencies. Occurrence of any development without runoff control or any development occurring within the designated storage sites, will force the use of a drainage-control system more complex than Alternative Plan II contemplates. These issues require immediate attention by the involved local agencies and should be brought to the attention of all affected citizens and their local governments.

CONCLUSIONS

Alternative Plan II is considered superior to Alternative Plan I primarily because it requires less extensive structural work within the sub-basin and it assures favorable water quality and low-flow conditions in the various tributaries and in North Creek.

Snohomish County, King County and the cities of Everett and Bothell should agree to establish a drainage master plan that incorporates provisions of Alternative Plan II. All agencies with jurisdiction should then move to implement and enforce the required runoff controls, establish flood-plain zoning and secure rights to the suggested storage areas. Because of the extensive land area within this sub-basin that is within the jurisdiction of Snohomish County, the County should have management responsibility for control of drainage and flood damage within the North Creek Sub-Basin. King County and the cities of Everett and Bothell should provide zoning, including flood-plain zoning, where necessary within their respective boundaries.

RUNOFF QUALITY SUMMARY
NORTH CREEK

BASED UPON A 10-YEAR STORM PRECEDED BY 15 DAYS WITH LITTLE OR NO RAINFALL#

LOCATION	ALTERNATIVE PLAN	PEAK FLOW (cfs)	CONCENTRATION AT PEAK FLOW*				
			BOD	TOTAL COLIFORM	NH_3	$NO_2 + NO_3$	PO_4
Mouth	I	1500	9	1.3×10^5	.2	.7	.2
Mouth	II	525	8	1.3×10^5	.2	.7	.2

Less than a total of 0.5 inches of rainfall in any one day.
* Concentrations in mg/liter except total coliform which is in MPN/100 ml.

NORTH CREEK

ALTERNATIVES	EFFECTIVENESS SUB TOTAL	Use of existing facilities	System reliability	System maintainability	System flexibility	Flood damage reduction	Consequences of overcharge	Erosion and sedimentation control	Cost/benefits ranking	HUMAN VALUES SUB TOTAL	Urban quality (aesthetics)	Effect on land use	Displacement of people	Educational value	Community cohesion	Multiple use potential	Public health and safety	ENVIRONMENTAL FACTORS SUB TOTAL	High flow conditions	Alteration of natural system	Effects on groundwater	Low flow conditions	Water quality	Construction disruption	Effects on wildlife	Effects on aquatic life	Effects on vegetation	IMPLEMENTATION SUB TOTAL	Legislative requirements	Jurisdictional	Land acquisition	Public acceptance	Financing	Effects of no action	RESOURCE REQUIREMENTS SUB TOTAL	Energy	Materials	Land	Capital	RATING TOTAL
CRITERIA WEIGHT		1	4	3	2	4	4	4	2		4	2	2	1	3	3	4		4	4	4	4	4	2	4	4	4		4	4	2	4	4	3		3	3	2	2	
I	-1									0								-28										-3							-8					-40
II	+8									+2								-2										-4							+2					+6

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative I   Sub-Basin North Creek

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
4	Culvert	4.5'	28'	0	3'	Replacement Culvert	6' x 15'	$17,000
7	Pipe	48"	450'			Parallel Pipe	48"	$50,000
10	Culvert	54"	80'			Parallel Culvert	60"	$19,000
13	Channel	5'	3,600'	.75:1	6'	Channel	6' width 6' depth 2:1 side slopes Streambank protection	$299,000
14	Channel	5'	3,750'	.75:1	6'	Channel	20' width 6' depth 2:1 side slopes Streambank protection	$390,000
15	Channel	5'	1,300'	.75:1	6'	Channel	10' width 6' depth 2:1 side slopes Streambank protection	$116,000
16	Channel	5'	2,000'	.75:1	6'	Channel	15' width 6' depth 2:1 side slopes Streambank protection	$192,000
17	Channel	5'	550'	.75:1	6'	Channel	8' width 6' depth 2:1 side slopes Streambank protection	$48,000
22	Culvert	5'	100'	0	3'	Replacement Culvert	8' x 3'	$29,000
24	Culvert	4'	100'	0	3'	Culvert	8' x 3'	$29,000
25	Channel	4'	3,200'	.75:1	6'	Channel	6' width 6' depth 2:1 side slopes Streambank protection	$326,000
27	Channel	2'	2,400'	1:1	2'	Diversion Pipe	48"	$227,000
83	Channel	5'	2,100'	1:1	3'	Channel	16' width 4' depth 2:1 side slopes	$33,000
28	Culvert	36"	40'			Replacement Culvert	10' x 4'	$14,000
29	Channel	5'	400'	3:1	2'	Channel	15' width 4' depth 2:1 side slopes	$7,000
30	Culvert	48"	40'			Replacement Culvert	10' x 4'	$14,000
31	Channel	10'	3,400'	1:1	2'	Channel	15' width 4' depth 2:1 side slopes	$58,000

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative I Sub-Basin North Creek

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
33	Channel	10'	5,200'	1:1	4'	Channel	16' width 4' depth 2:1 side slopes	$56,000
43	Channel	10'	2,100'	.75:1	10'	Channel	10' width 10' depth 2:1 side slopes Streambank protection	$310,000
44	Channel	15'	3,000'	1:1	3'	Channel	125' width 3' depth 2:1 side slopes Streambank protection	$373,000
45	Channel	15'	4,800'	1:1	3'	Channel	150' width 3' depth 2:1 side slopes Streambank protection	$684,000
46	Channel	15'	1,250'	1:1	3'	Channel	80' width 3' depth 2:1 side slopes Streambank protection	$111,000
47	Channel	16'	500'	1:1	6'	Channel	20' width 6' depth 2:1 side slopes Streambank protection	$42,000
49	Channel	16'	1,300'	1:1	6'	Channel	20' width 6' depth 2:1 side slopes Streambank protection	$109,000
50	Channel	16'	1,600'	1:1	6'	Channel	20' width 6' depth 2:1 side slopes Streambank protection	$135,000
51	Channel	16'	600'	1:1	6'	Channel	35' width 6' depth 2:1 side slopes	$22,000
52	Channel	5'	2,900'	1:1	5'	Diversion Pipe	48"	$274,000
53	Culvert	10'	60'	0	5'	Parallel Culvert	48"	$13,000
54	Channel	5'	4,000'	1:1	5'	Diversion Pipe	48"	$380,000
55	Culvert	6'	60'	0	3'	Parallel Culvert	60"	$17,000
58	Channel	2'	3,500'	1:1	2'	Diversion Pipe	48"	$333,000
59	Channel	2'	7,000'	1:1	2'	Channel	4' width 3' depth 1:1 side slopes Streambank protection	$122,000
62	Channel	2'	2,900'	1:1	2'	Channel	6' width 2.5' depth 2:1 side slopes Streambank protection	$102,000
63	Channel	10'	1,100'	1:1	4'	Channel	15' width 4' depth 2:1 side slopes Streambank protection	$62,000

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative I Sub-Basin North Creek

	EXISTING FACILITIES					PROPOSED FACILITIES		
ELEMENT NUMBER	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
64	Channel	9'	1,000	1:1	7'	Channel	30' width 7' depth 2:1 side slopes Streambank protection	$126,000
65	Culvert	15'	22'	0	7.5'	Bridge	20' width 7' depth 2:1 side slopes Streambank protection	$18,000
66	Channel	15'	2,900'	1:1	7'	Channel	30' width 7' depth 2:1 side slopes Streambank protection	$346,000
68	Channel	15'	3,700'	1:1	5'	Channel	60' width 5' depth 2:1 side slopes Streambank protection	$446,000
69	Channel	20'	2,500'	3:1	3'	Channel	175' width 3' depth 1:1 side slopes Streambank protection	$348,000
70	Culvert	23'	30'	0	5'	Bridge	100' width 4' depth Vertical side slopes	$78,000
71	Channel	10'	1,100'	1:1	7'	Channel	40' width 7' depth 1:1 side slopes Streambank protection	$113,000
73	Culvert	2'	60'			Parallel Culvert	18"	$5,000
74	Channel	2'	1,100'	1:1	2'	Channel	4' width 2' depth 1:1 side slopes Streambank protection	$18,000
75	Channel	10'	2,900'	1:1	7'	Channel	40' width 7' depth 2:1 side slopes Streambank protection	$424,000
76	Channel	21'	1,000'	1:1	3'	Channel	300' width 3' depth 1:1 side slopes	$220,000
77	Culvert	23'	30'	0	5'	Bridge	175' width 3' depth 2:1 side slopes	$98,000
78	Channel	21'	4,100'	1:1	3'	Channel	300' width 3' depth 1:1 side slopes	$900,000
80	Channel	20'	800'	1:1	4'	Channel	80' width 4' depth 1:1 side slopes	$48,000
82	Channel	20'	3,700'	1:1	4'	Channel	80' width 4' depth 1:1 side slopes	$224,000
1	Channel	5'	600'	.75:1	6'	Channel	Streambank protection	$23,000
2	Channel	5'	2,900'	.75:1	6'	Channel	Streambank protection	$111,000

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative I Sub Basin North Creek

	EXISTING FACILITIES					PROPOSED FACILITIES		
ELEMENT NUMBER	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
3	Channel	5'	625'	.75:1	6'	Channel	Streambank protection	$24,000
5	Channel	5'	600'	.75:1	6'	Channel	Streambank protection	$23,000
6	Channel	5'	1,150'	.75:1	6'	Channel	Streambank protection	$44,000
8	Channel	5'	1,650'	.75:1	6'	Channel	Streambank protection	$63,000
9	Channel	5'	650'	.75:1	6'	Channel	Streambank protection	$25,000
11	Channel	5'	600'	.75:1	6'	Channel	Streambank protection	$23,000
12	Channel	5'	350'	.75:1	6'	Channel	Streambank protection	$14,000
34	Channel	10'	800'	1:1	4'	Channel	Streambank protection	$23,000
36	Channel	10'	2,850'	1:1	4'	Channel	12' width 4' depth 1:1 side slopes Streambank protection	$87,000
37	Channel	10'	500'	1:1	4'	Channel	15' width 4' depth 1:1 side slopes Streambank protection	$17,000
39	Channel	10'	700'	1:1	4'	Channel	15' width 4' depth 1:1 side slopes Streambank protection	$24,000
42	Channel	9'	600'	1:1	4.5'	Channel	Streambank protection	$19,000
61	Channel	2'	2,700'	2:1	2'	Channel	Streambank protection	$61,000
72	Channel	2'	1,600'	1:1	2'	Channel	Streambank protection	$23,000
56	Channel	5'	1,500'	1:1	5'	Channel	Streambank protection	$54,000
35	Channel	12'	2,900'	2:1	4'	Channel	15' width 4' depth 2:1 side slopes	$9,000

The Estimated Capital Cost for each element includes Contractor profit, engineering, legal and contingencies. In addition, land purchase and severance costs are included where land is required. All costs are based upon June 1973 prices.

Total Estimated Capital Cost: $9,092,000
Round To: $9,100,000

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative II Sub Basin North Creek

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
4	Culvert	4.5'	28'	0	3'	Replacement Culvert	8' x 3'	$9,000
7	Pipe	48"	450'			Replacement Culvert	7' x 4'	$143,000
10	Culvert	54"	80'			Replacement Culvert	7' x 4'	$25,000
14	None					Holding Pond	20 AF	$163,000
21	None					Outlet	Outlet control device on Silver Lake	$4,000
27	Channel	2'	2,400'	1:1	2'	Diversion Pipe	36"	$161,000
26	None					Outlet	Outlet control on Ruggs Lake	$3,000
83	Channel	5'	2,100'	1:1	3'	Channel	6' width 4' depth 2:1 side slopes	$18,000
31	Channel	10'	3,400'	1:1	2'	Channel	8' width 4' depth 2:1 side slopes	$34,000
44	None					Holding Pond	30 AF storage flood plain zone	-0-
58	None					Holding Pond	1.3 AF	$32,000
59	Channel	2'	7,000'	1:1	2'	Diversion Pipe	18" Streambank protection	$367,000
75	Channel	10'	2,900'	1:1	7'	Channel	Flood plain zone	-0-
76	Channel	21'	1,000'	1:1	3'	Channel	Flood plain zone	-0-
78	Channel	21'	4,100'	1:1	3'	Channel	Flood plain zone	-0-
74	Channel	2'	1,100'	1:1	2'	Channel	Streambank protection	$16,000
80	Channel	20'	800'	1:1	4'	Channel	Streambank protection	$23,000

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative II   Sub-Basin North Creek

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
62	Channel	2'	2,900'	2:1	2'	Channel	Streambank protection	$65,000
63	Channel	10'	1,100'	1:1	4'	Channel	Flood plain zone Streambank protection	$31,000
64	Channel	9'	1,000'	1:1	7'	Channel	Streambank protection	$57,000
68	Channel	15'	3,700'	1:1	5'	Channel	Streambank protection	$131,000
69	Channel	20'	2,500'	3:1	3'	Channel	Streambank protection	$119,000
72	Channel	2'	1,600'	1:1	2'	Channel	Streambank protection	$23,000
49	Channel	16'	1,300'	1:1	6'	Channel	Streambank protection	$56,000
50	Channel	16'	1,600'	1:1	6'	Channel	Streambank protection	$68,000
52	Channel	5'	2,900'	1:1	5'	Channel	Streambank protection	$103,000
54	Channel	5'	4,000'	1:1	5'	Channel	Streambank protection	$142,000
56	Channel	5'	1,500'	1:1	5'	Channel	Streambank protection	$54,000
61	Channel	2'	2,700'	2:1	2'	Channel	Streambank protection	$61,000
36	Channel	10'	2,850'	1:1	4'	Channel	Streambank protection	$81,000
37	Channel	10'	500'	1:1	4'	Channel	Streambank protection	$14,000
39	Channel	10'	700'	1:1	4'	Channel	Streambank protection	$20,000
42	Channel	9'	600'	1:1	4.5'	Channel	Streambank protection	$19,000
43	Channel	10'	2,100'	.75:1	10'	Channel	Streambank protection	$134,000

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

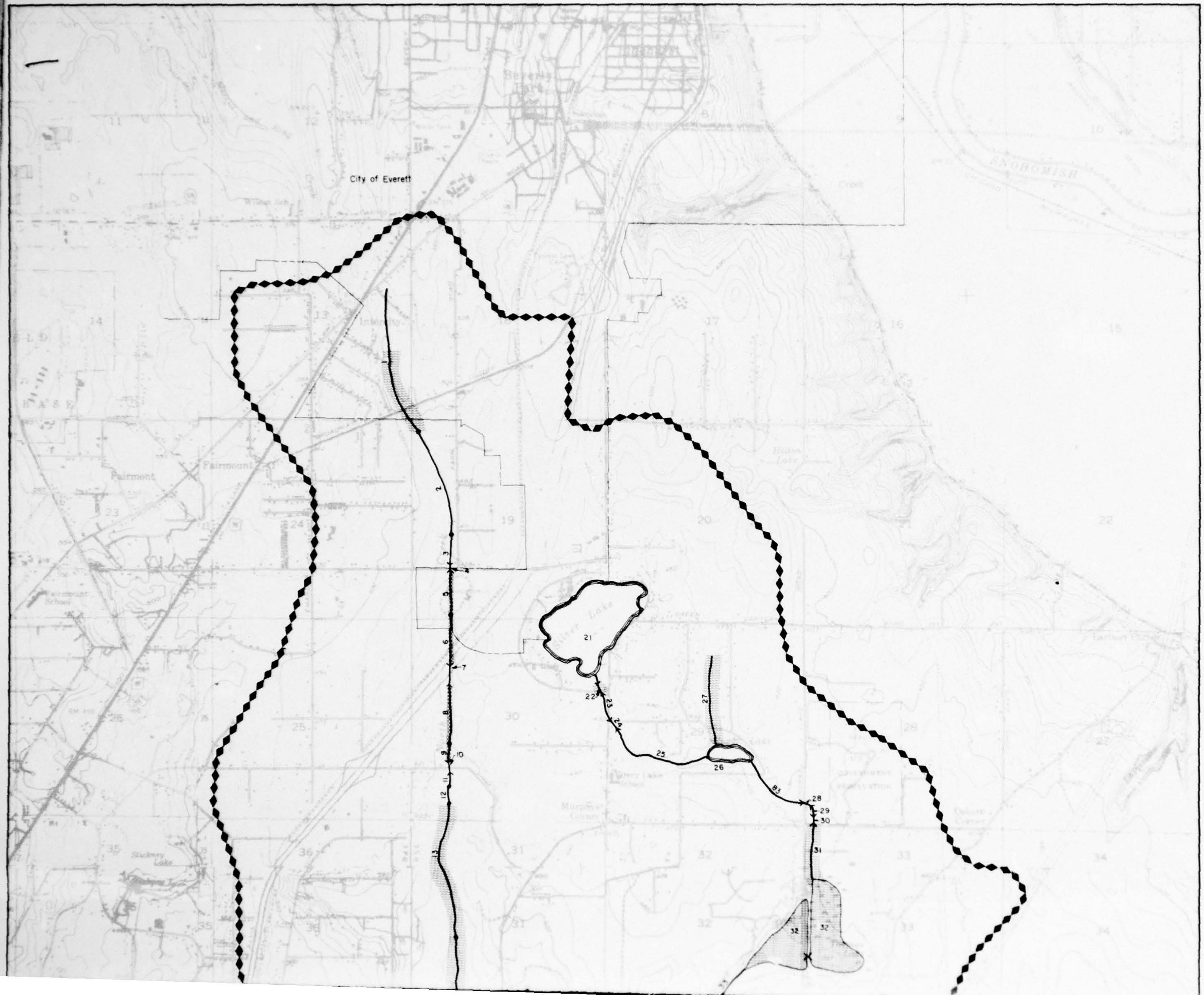
Alternative II Sub-Basin North Creek

	EXISTING FACILITIES					PROPOSED FACILITIES		
ELEMENT NUMBER	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
46	Channel	15'	1,250'	1:1	3'	Channel	Streambank protection	$27,000
47	Channel	16'	500'	1:1	6'	Channel	Streambank protection	$22,000
11	Channel	5'	600'	.75:1	6'	Channel	Streambank protection	$23,000
12	Channel	5'	350'	.75:1	6'	Channel	Streambank protection	$14,000
13	Channel	5'	3,600'	.75:1	6'	Channel	Streambank protection	$138,000
15	Channel	5'	1,300'	.75:1	6'	Channel	Streambank protection	$50,000
16	Channel	5'	2,000'	.75:1	6'	Channel	Streambank protection	$77,000
17	Channel	5'	550'	.75:1	6'	Channel	Streambank protection	$21,000
34	Channel	10'	800'	1:1	4'	Channel	Streambank protection	$23,000
1	Channel	5'	600'	.75:1	6'	Channel	Streambank protection	$23,000
2	Channel	5'	2,900'	.75:1	6'	Channel	Streambank protection	$111,000
3	Channel	5'	625'	.75:1	6'	Channel	Streambank protection	$24,000
5	Channel	5'	600'	.75:1	6'	Channel	Streambank protection	$23,000
6	Channel	5'	1,150'	.75:1	6'	Channel	Streambank protection	$44,000
8	Channel	5'	1,650'	.75:1	6'	Channel	Streambank protection	$63,000
9	Channel	5'	650'	.75:1	6'	Channel	Streambank protection	$25,000
28	Culvert	36"	40'	-	-	Parallel Culvert	30"	$7,000

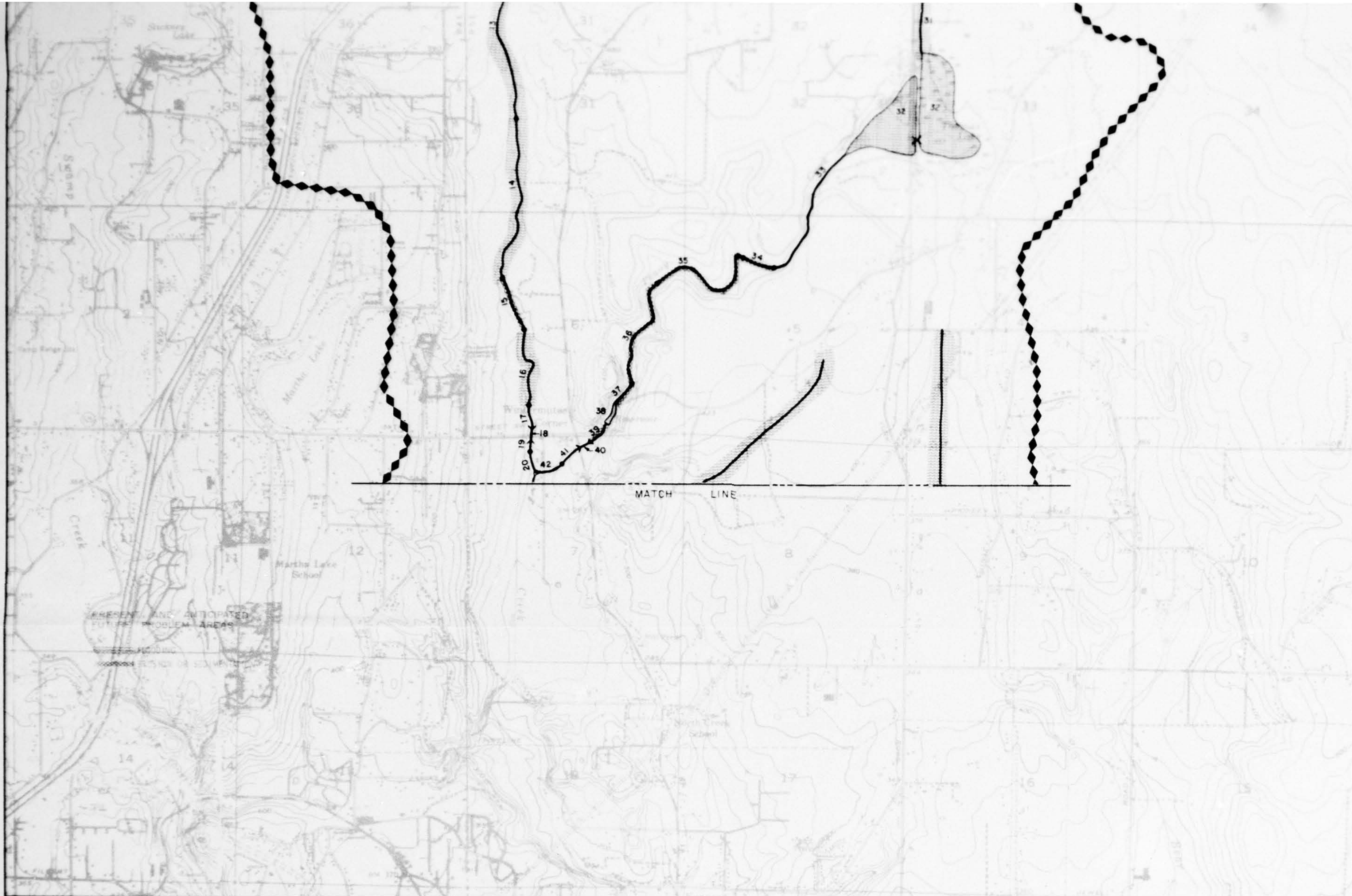
The Estimated Capital Cost for each element includes Contractor profit, engineering, legal and contingencies. In addition, land purchase and severance costs are included where land is required. All costs are based upon June 1973 prices.

Total Estimated Capital Cost: $2,891,000

Round To: $2,900,000



City of Everett
SNOHOMISH
Fairmount
Murphys Corner



LEGEND

SUB-BASIN BOUNDARY	
EXISTING CHANNEL	
EXISTING CONDUIT	
MANHOLE, INLET, OR JUNCTION	
CHANNEL OR CONDUIT DESIG.	5
CITY LIMITS	
COUNTY (METRO) BOUNDARY	
LEVEE	
CULVERT	
HOLDING POND OR LAKE	

N

1/2 1/4 0 1
MILES

1000 500 0 4000
FEET

NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

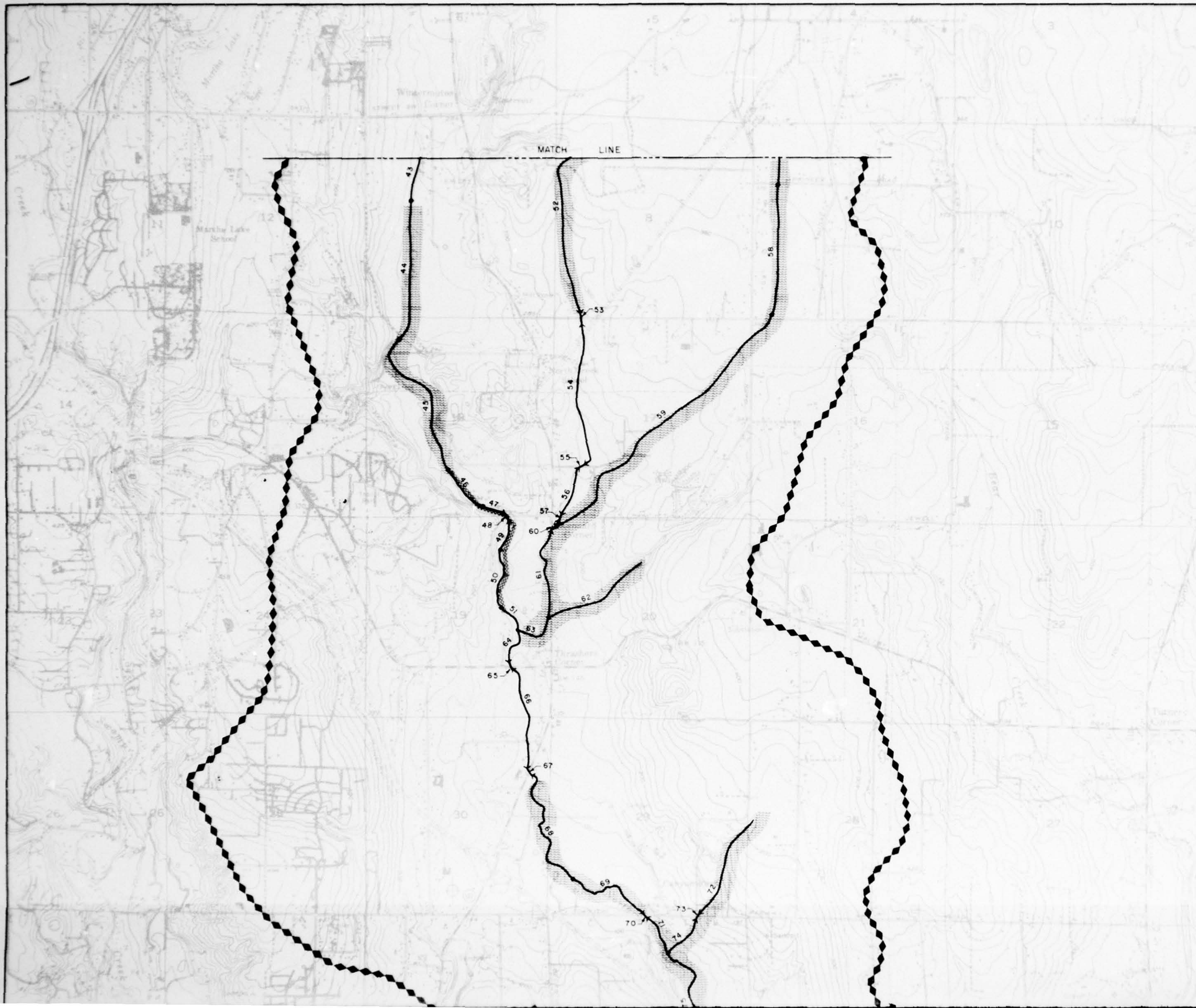
NORTH CREEK

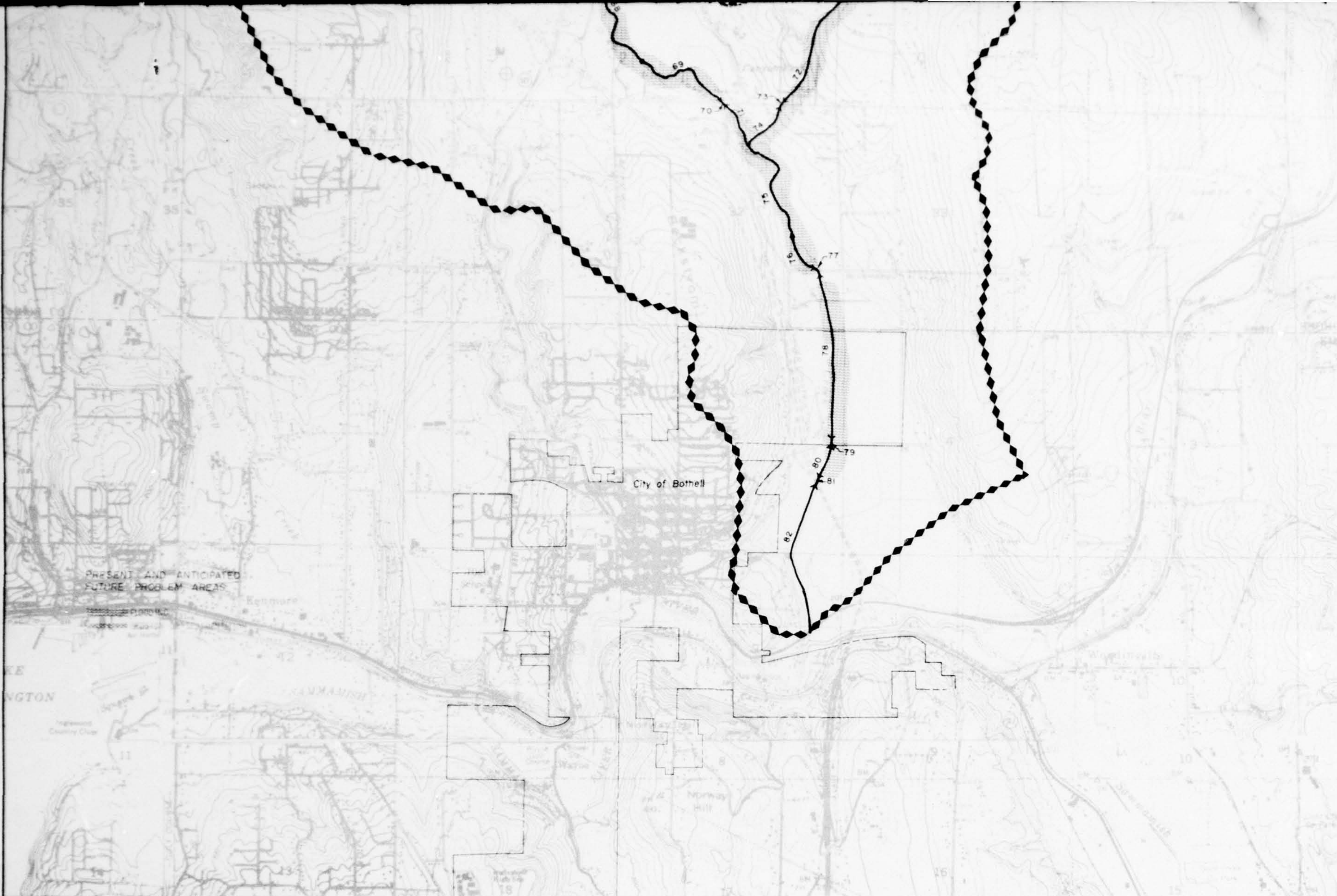
PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

KRAMER, CHIN AND MAYO, INC
WATER RESOURCES ENGINEERS, INC
YODER, TROTTER, ORLOB & ASSOCIATES

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO E-26-1-161 SHEET [illegible] OF 2


MATCH LINE
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60
61
62
63
64
65
66
67
68
69
70
71
72
73
74



LEGEND

SUB-BASIN BOUNDARY
EXISTING CHANNEL
EXISTING CONDUIT
MANHOLE, INLET, OR JUNCTION
CHANNEL OR CONDUIT DESIG — 5
CITY LIMITS
COUNTY (METRO) BOUNDARY
LEVEE
CULVERT
HOLDING POND OR LAKE

N

1/2 — 1/4 — 0 — 1 MILES

1000 — 500 — 0 — 4000 FEET

NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

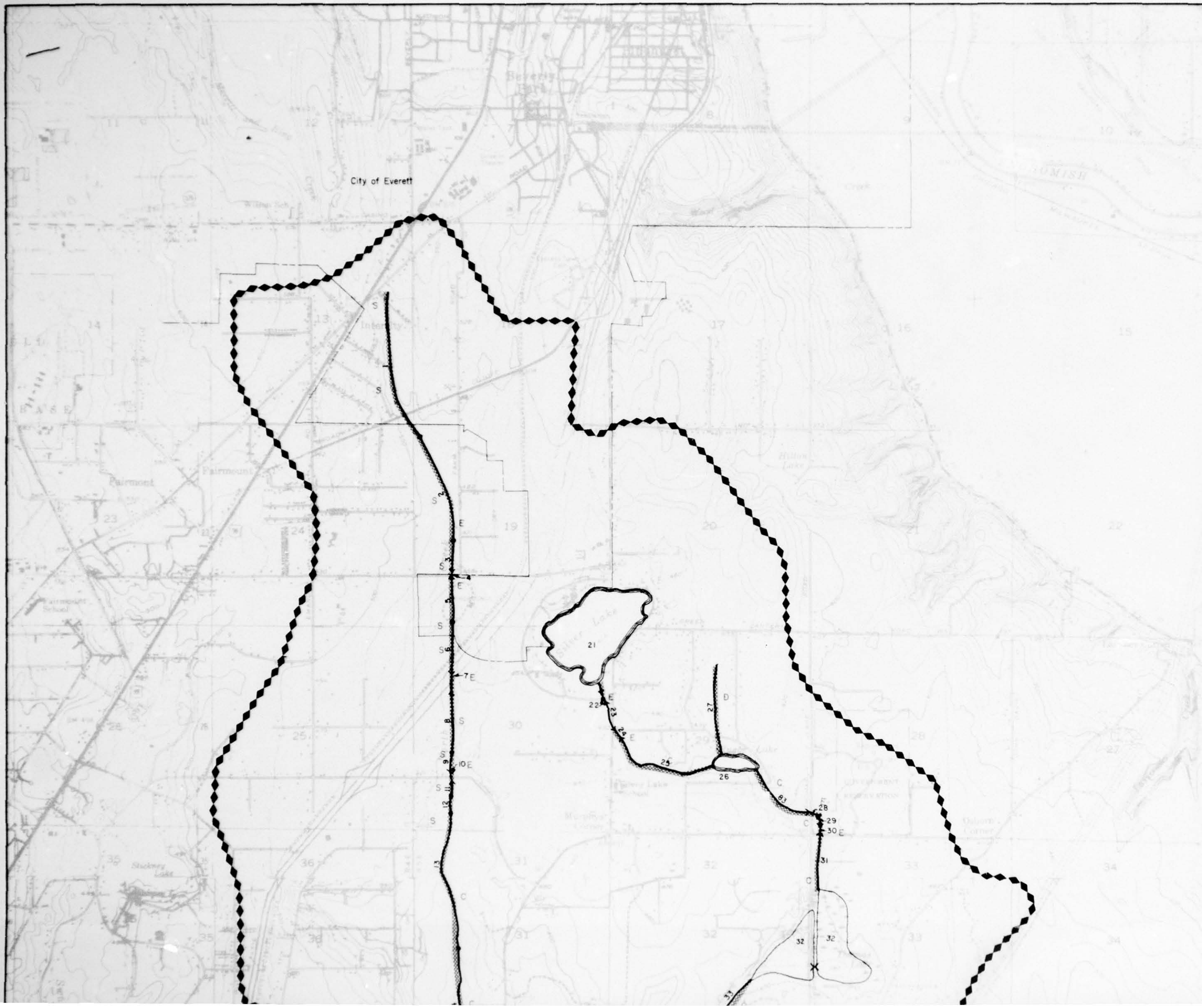
NORTH CREEK

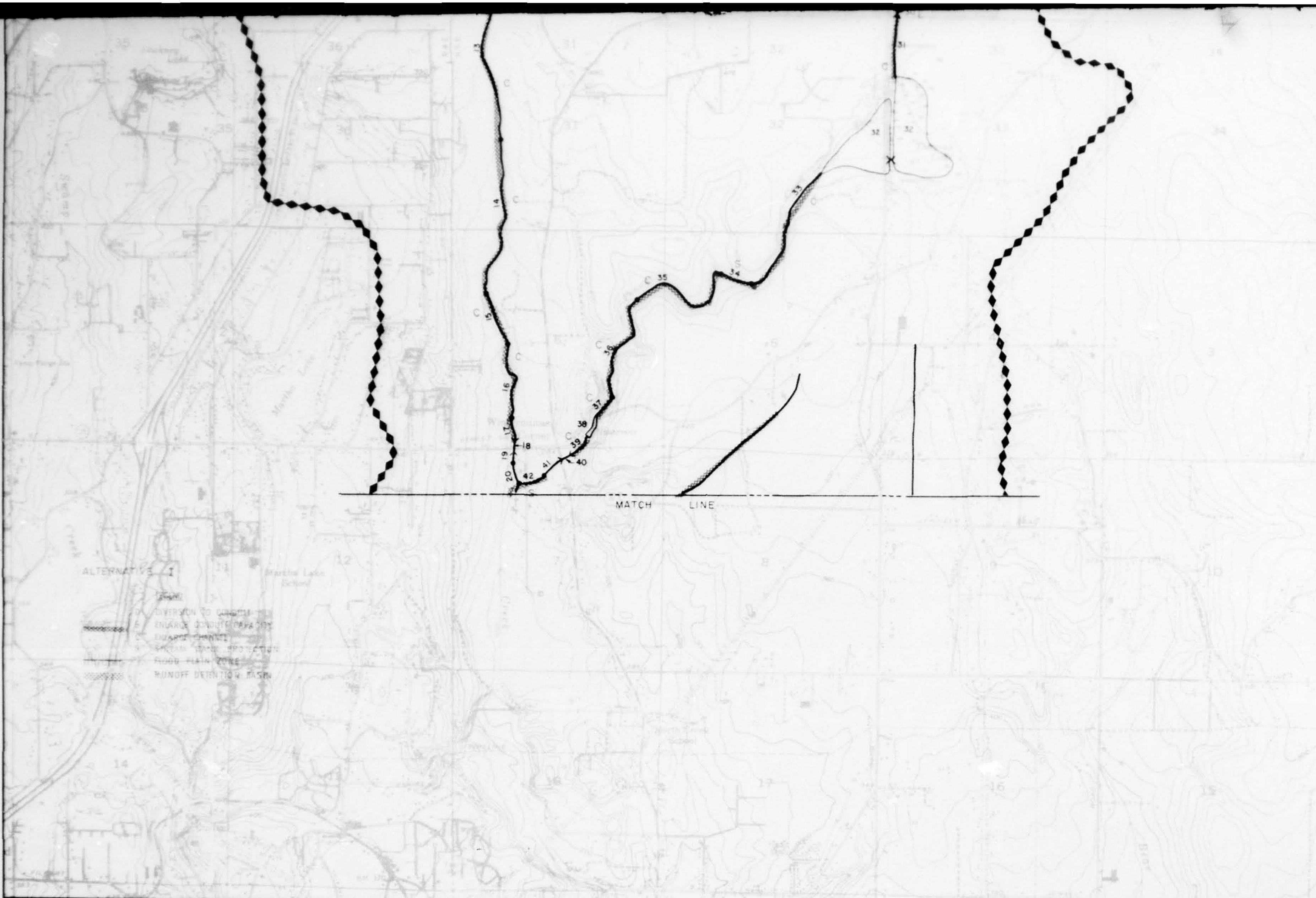
PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

KRAMER, CHIN AND MAYO, INC
WATER RESOURCES ENGINEERS, INC
YODER, TROTTER, ORLOB & ASSOCIATES

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO E-26-1-161 SHEET 2 OF 2


City of Everett
Beverly Park
Fairmont
Silver Lake
Stickney Lake
Hilton Lake
Murphys Corner
Silver Lake School
Osborn Corner



LEGEND

- SUB-BASIN BOUNDARY
- EXISTING CHANNEL
- EXISTING CONDUIT
- MANHOLE, INLET, OR JUNCTION
- CHANNEL OR CONDUIT DESIG
- CITY LIMITS
- COUNTY (METRO) BOUNDARY
- LEVEE
- CULVERT
- HOLDING POND OR LAKE

NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

NORTH CREEK

PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

KRAMER, CHIN AND MAYO, INC
WATER RESOURCES ENGINEERS, INC
YODER, TROTTER, ORLOB & ASSOCIATES

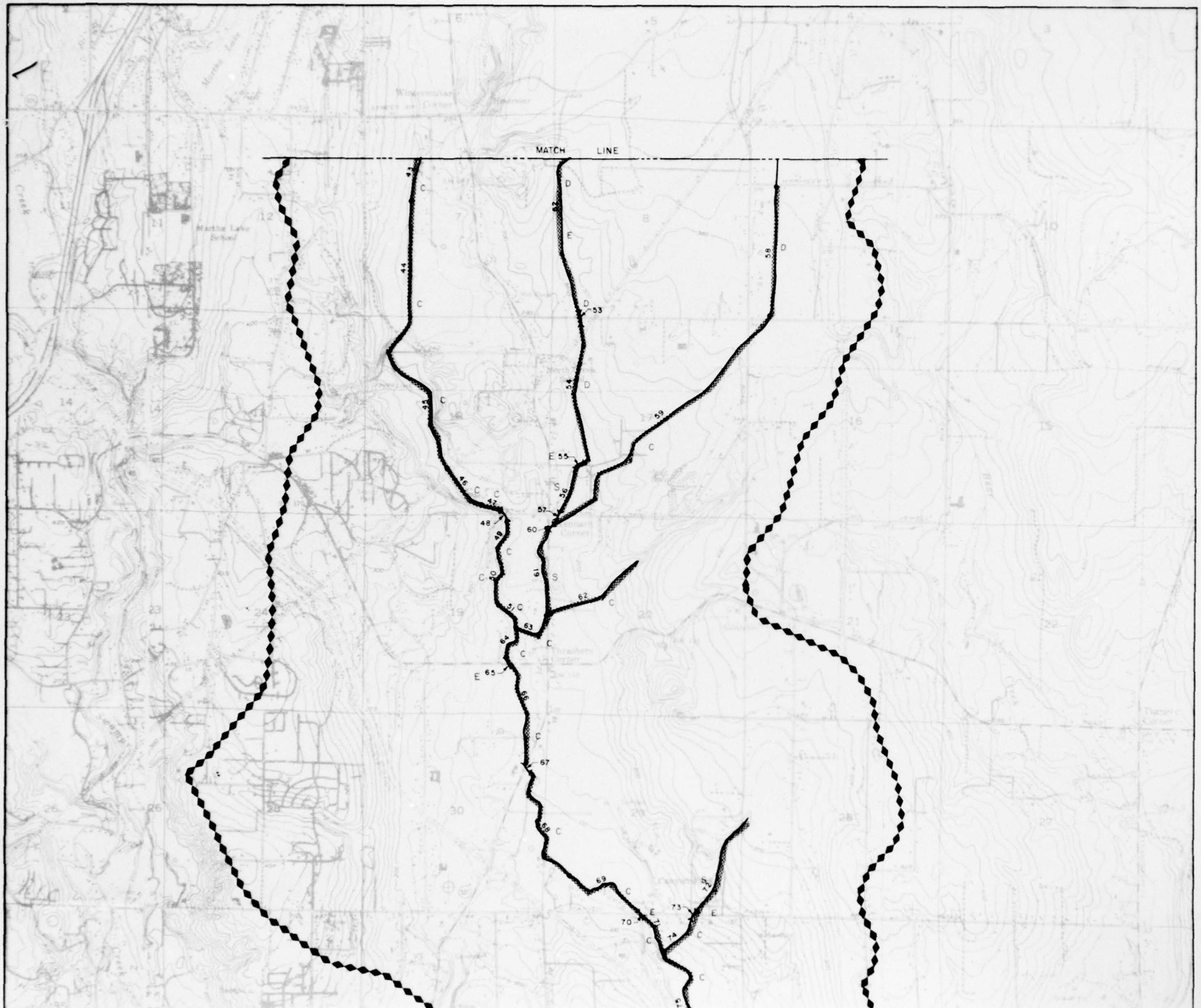
U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO E-26-1-161 SHEET 10 OF 2

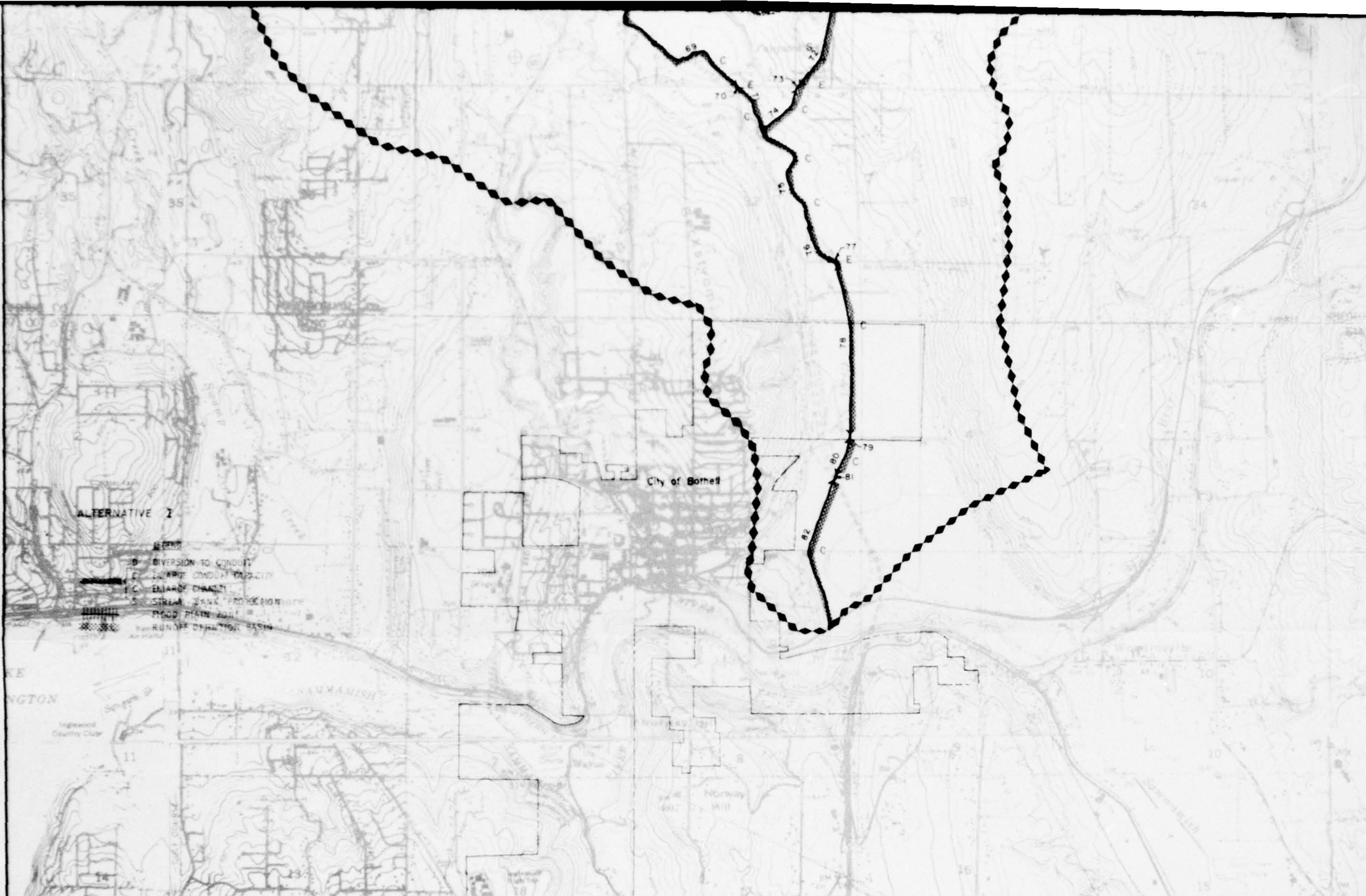
AD-A042 166 KCM-WRE/YTO SEATTLE WASH F/G 8/8
ENVIRONMENTAL PLANNING FOR THE METROPOLITAN AREA CEDAR-GREEN RI--ETC(U)
DEC 74 DACW67-73-C-0022

UNCLASSIFIED NL

3 OF 6
AD
A042166



MATCH LINE
Martha Lake School
Creek



LEGEND

SUB-BASIN BOUNDARY
EXISTING CHANNEL
EXISTING CONDUIT
MANHOLE, INLET, OR JUNCTION
CHANNEL OR CONDUIT DESIG. 5
CITY LIMITS
COUNTY (METRO) BOUNDARY
LEVEE

CULVERT
HOLDING POND OR LAKE

N

1/2 1/4 0 1 MILES

1000 500 0 4000 FEET

NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

NORTH CREEK

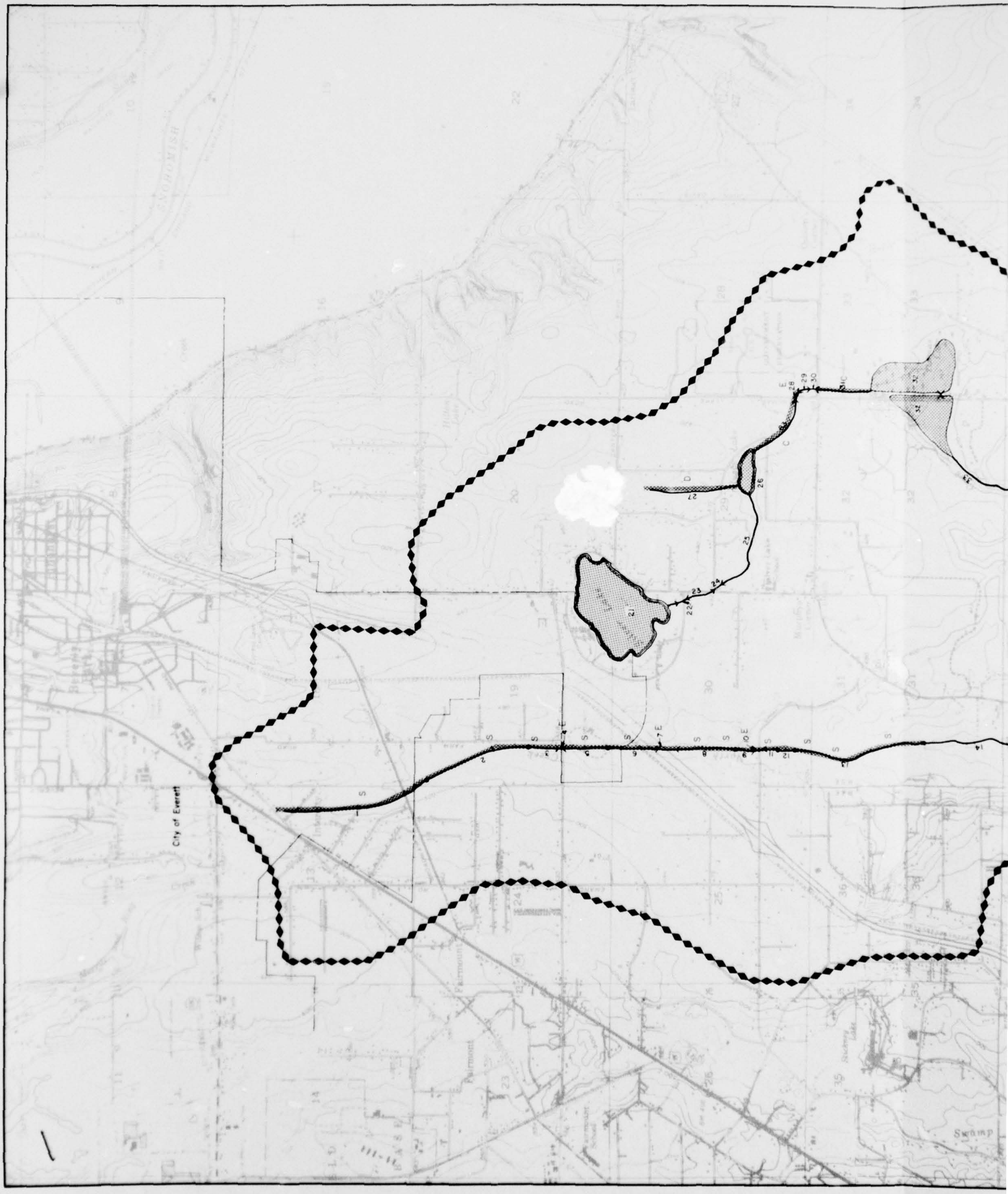
PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

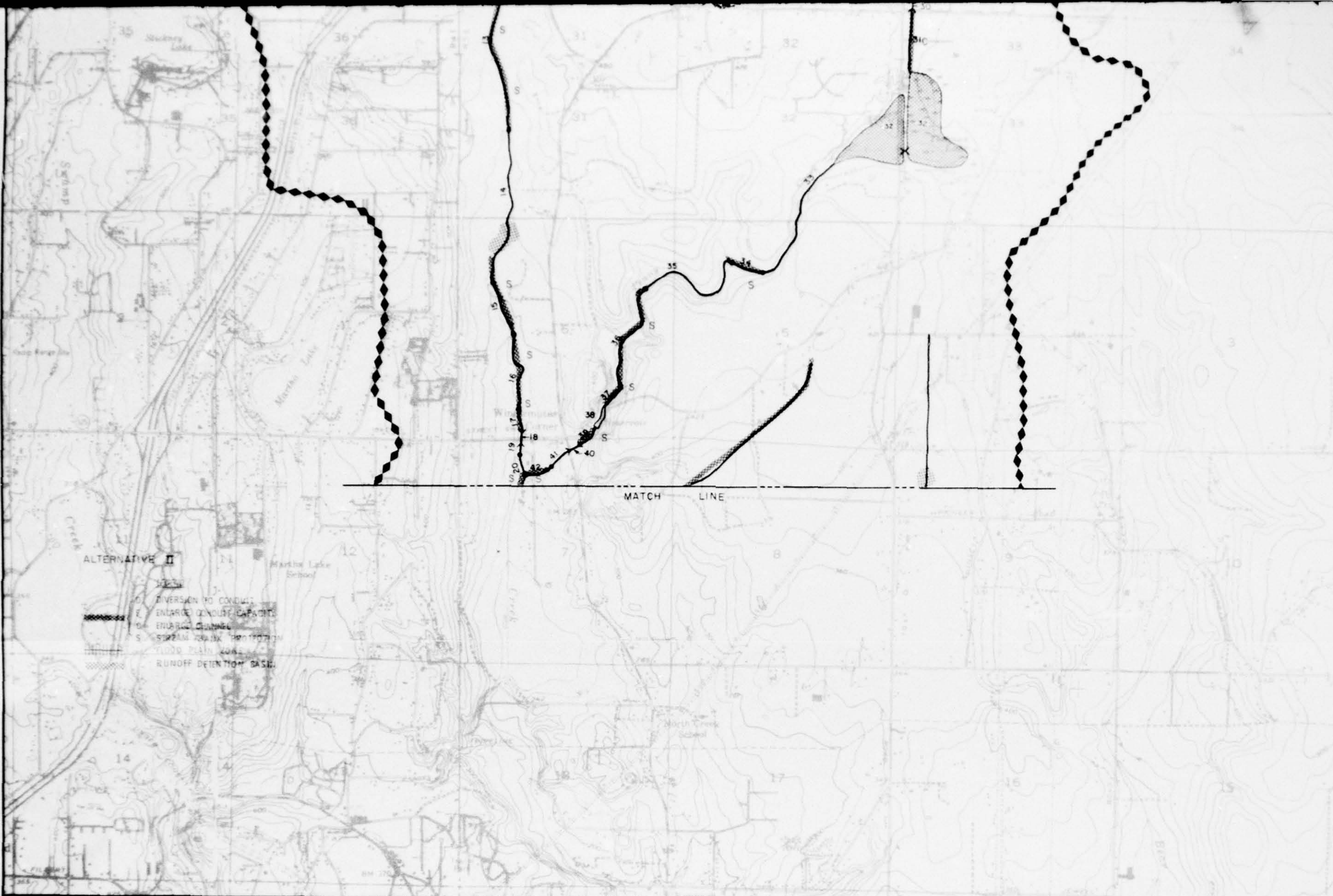
KRAMER, CHIN AND MAYO, INC.
WATER RESOURCES ENGINEERS, INC.
YODER, TROTTER, ORLOB & ASSOCIATES

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO E-26-1-161 SHEET 2b OF 2

2


City of Everett
Swamp



LEGEND

SUB-BASIN BOUNDARY
EXISTING CHANNEL
EXISTING CONDUIT
MANHOLE, INLET, OR JUNCTION
CHANNEL OR CONDUIT DESIG
CITY LIMITS
COUNTY (METRO) BOUNDARY
LEVEE
CULVERT
HOLDING POND OR LAKE

N

MILES: 1/2 1/4 0 1

FEET: 1000 500 0 4000

NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

NORTH CREEK

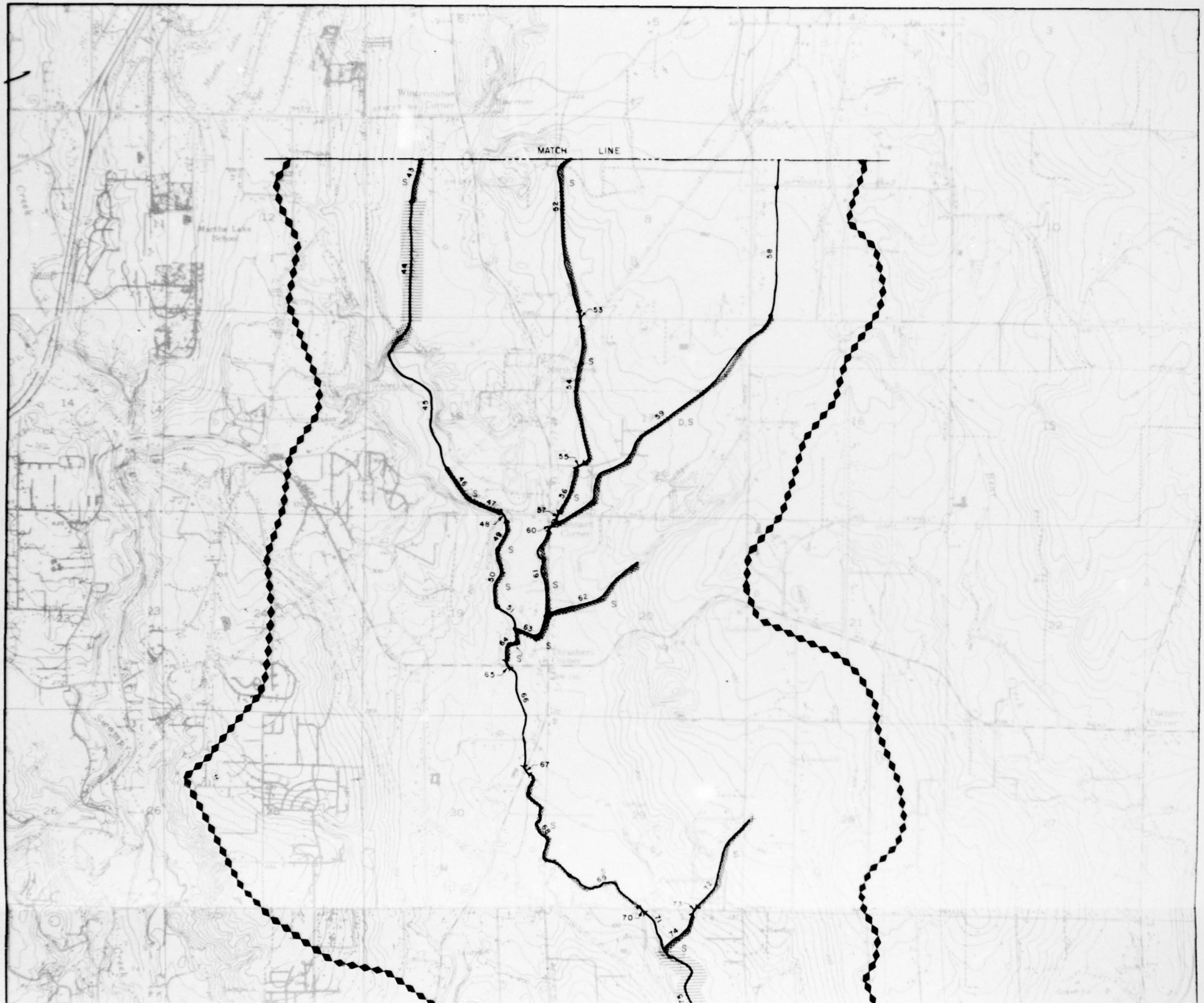
PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

KRAMER, CHIN AND MAYO, INC
WATER RESOURCES ENGINEERS, INC
YODER, TROTTER, ORLOB & ASSOCIATES

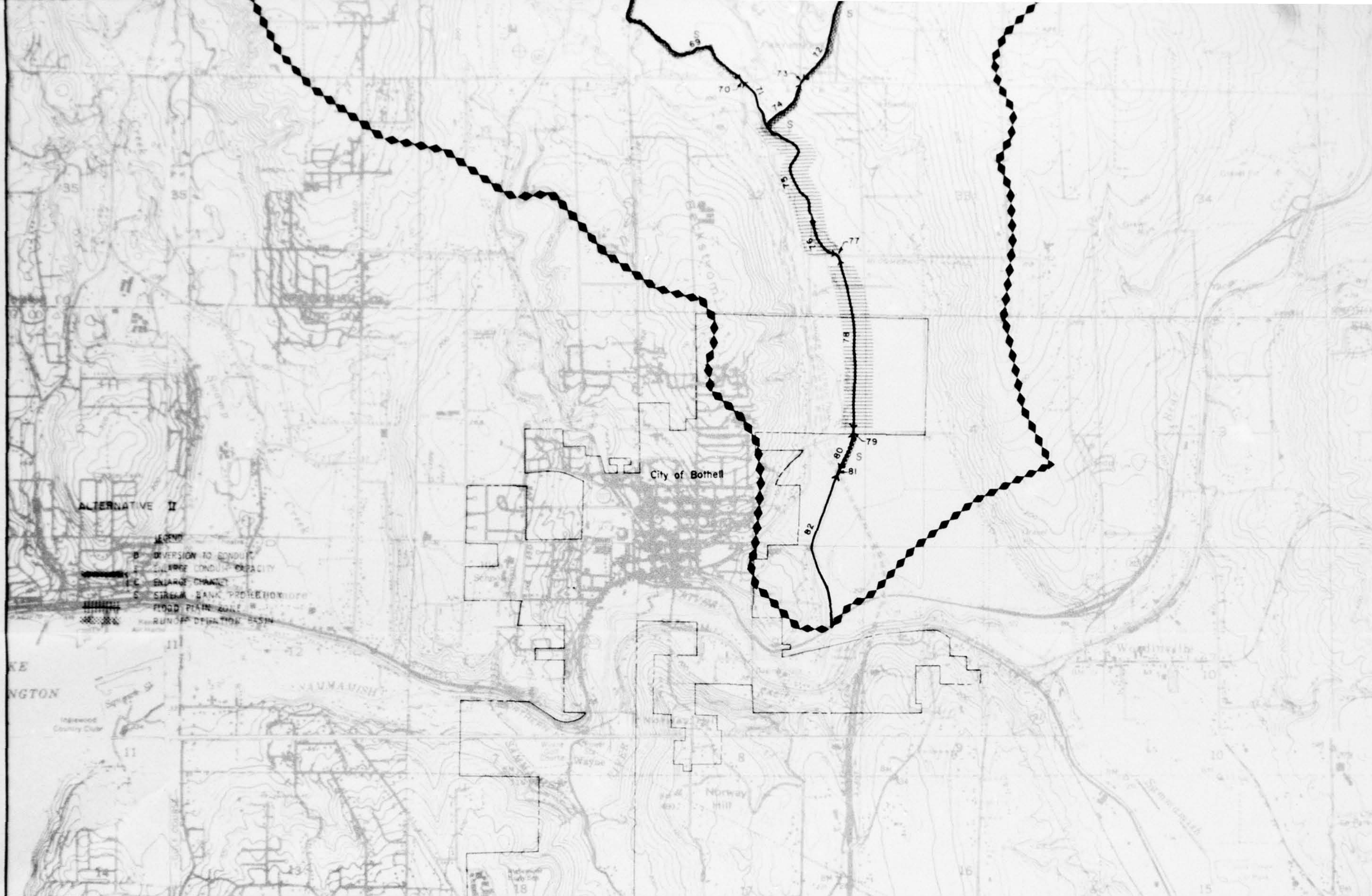
U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO E-26-1-161 SHEET F OF 2

2



MATCH LINE



LEGEND

- SUB-BASIN BOUNDARY
- EXISTING CHANNEL
- EXISTING CONDUIT
- MANHOLE, INLET, OR JUNCTION
- CHANNEL OR CONDUIT DESIG. — 5
- CITY LIMITS
- COUNTY (METRO) BOUNDARY
- LEVEE
- CULVERT
- HOLDING POND OR LAKE

N

1/2 1/4 0 1
MILES
1000 500 0 4000
FEET

NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

NORTH CREEK

PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

KRAMER, CHIN AND MAYO, INC.
WATER RESOURCES ENGINEERS, INC.
YODER, TROTTER, ORLOB & ASSOCIATES

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO. E-26-1-161 SHEET 2c OF 2

2

REGIONAL SUB-BASIN C-8

SWAMP CREEK

GENERAL DESCRIPTION

Swamp Creek Sub-Basin is located north of Lake Washington within the Cedar River basin. The sub-basin drains from north to south from Paine Field through the Swamp Creek freeway interchange and Alderwood Manor. It discharges to the Sammamish River at Kenmore. Generally, it is bounded on the west by State Highway 99 and on the east by Martha Lake and Bothell. The basin is approximately 11 miles long and two and a half miles wide.

The sub-basin geography is typical of Puget Sound uplands, with gently sloping uplands and generally narrow valley plains adjacent to the creeks that drain the sub-basin. The sub-basin is intersected by freeways I-5 and I-405.

The principal streams in the sub-basin are Swamp Creek, approximately nine miles long and Scribber Creek, approximately three miles long. Scribber Creek drains the Lynnwood-Alderwood Manor area in a southeasterly direction and joins Swamp Creek five and a half miles above the confluence with the Sammamish River. Three lakes are in the sub-basin. Stickney Lake forms the headwaters of Swamp Creek. Martha Lake, the largest of the three, drains through a small tributary to Swamp Creek just before it flows beneath I-405. Scribber Lake in Lynnwood is a small neighborhood lake of less than five acres. It is the origin of Scribber Creek. A wetland area of approximately 100 acres is located above the Swamp Creek Interchange I-5. The area is valuable as a wildlife habitat, and has a significant hydraulic benefit by attenuating high flows in Swamp Creek.

Streams	Category	Drainage Area	Discharge
Swamp Creek	III	24 sq. mi.	Sammamish River
Scribber Creek	III	6.6 sq. mi.	Swamp Creek

Present development of the sub-basin is approximately 74% single-family residential with a mixture of subdivision and rural densities. The Lynnwood, Paine Field, and Kenmore areas have considerable expanses of commercial development. Only small portions of the creek's length are not committed to residential-land activity.

PERCENT OF SUB-BASIN AREA IN SPECIFIED LAND USE

Land Use	Existing (1970-72)	P.S.G.C Land Use Projection Comprehensive	Corridor
Single Family	74	75	66
Multiple Family	1	3	10
Commercial/Services	3	8	5
Govt. and Educ.	1	2	2
Industrial		2	2
Parks/Dedicated Open Space	5	3	3
Agriculture	5	5	5
Airports, Railyards Freeways, Highways	1	2	2
Unused Land	10		5
Water			
Total	100	100	100
Total Impervious Area	15	35	35

Future development in the sub-basin will probably consist of an intensification of single-family residential areas and an increase of commercial and multiple-family residential areas. Some existing open lands, which are presently adjacent to existing urban centers, may be developed for commercial use, such as the proposed Alderwood Mall at Lynnwood.

Five governmental agencies have drainage responsibilities within the sub-basin; Snohomish County, 70% of basin area, Lynnwood 23%, King County 5%, Brier 1%, and Mountlake Terrace 1%. Swamp Creek is within the Metro sewer service area. Metro will provide sewage-treatment service to portions of the sub-basin by contract with the Alderwood Water District.

NATURE OF EXISTING DRAINAGE SYSTEM

Generally, the streams of the sub-basin are in a natural condition. Swamp Creek's flow is controlled by a series of culverts at the

Swamp Creek Interchange and at the downstream crossing of I-405. The wetlands area immediately above the Swamp Creek Interchange attenuates downstream flow. Scribber Creek is controlled by a culvert under I-5 near Lynnwood. Lynnwood is the only area that has a significant man-made storm drainage system. The drains discharge urban runoff to Scribber Creek and two of its small tributaries.

Swamp Creek experiences runs of coho, cutthroat, kokanee. The west branch is an important habitat for young fish. Swamp Creek also supports chinook and sockeye salmon runs, and portions of the creek have been used to determine the extent of salmon spawning.

DRAINAGE PROBLEMS

The major reported drainage problem within Swamp Creek is overbank flooding. Presently, Swamp Creek floods above the Swamp Creek Interchange of I-5 and I-405. Various road culverts in the upper reaches of the stream also are surcharged. Swamp Creek overflows its banks below the confluence of Swamp Creek and Scribber Creek. Sedimentation and collection of debris is a problem in the lower portion of the stream before it enters the Sammamish River.

Scribber Creek, a main tributary of Swamp Creek, experiences some flooding in the Lynnwood and Alderwood Manor areas.

Water pollution in the creeks, caused by septic tank effluent, is expected to be controlled by the installation of sewers, but runoff from urban development could continue to degrade water quality.

Flooding problems intensify when projected with future land-use plans. Additional flooding is predicted when drainage considerations are related to the 2000 Comprehensive Land Use Plan and the 2000 Corridor Land Use Plan. The intensity of the problems vary when alternative drainage plans are used for projection.

Land-use projections for the year 2000, under both the Comprehensive and Corridor Land Use Plans, indicate that a significant portion of the Swamp Creek Sub-Basin will be covered by impervious surfaces. The total impervious area in this sub-basin under existing conditions is approximately 15% and is projected under either plan to increase to approximately 35% of the total land area.

The 2000 Comprehensive Land Use Plan generates greater flows and therefore more critical problems would be expected in the upper reaches of Swamp Creek as compared with the 2000 Corridor Land Use Plan. The estimated future flows from Martha Lake are greater for the Corridor Plan than for the Comprehensive Plan. The flows originating in the Lynnwood area, and below the confluence of Swamp and Scribber Creeks, are approximately equal for either land use plan.

BASIC ISSUES AND STATUS OF DRAINAGE PLANNING

The cities of Lynnwood and Mountlake Terrace have prepared drainage master plans. No downstream impacts upon Scribber Creek were assessed during preparations of the plans. King County has no formal plans within the sub-basin. Snohomish County prepared a broad drainage plan for the county section of Swamp Creek in their WASH-USE-1 study but did not consider impact upon down-stream reaches in King County. No complete sub-basin plan has been developed. Coordination between any of the agencies, especially Snohomish County and King County, has been hampered by lack of monetary and manpower sources.

Snohomish County, the agent which controls the largest area within the watershed, has a general drainage policy for preservation of the natural drainage system that limits runoff to near natural rates, especially from industrial and commercial areas, and prohibits all intensive land-use development within the 100-year flood plain. These general policies are compatible with the philosophy for maintaining a natural stream environment, a preference for which has been expressed by the public during the RIBCO study. King County, through its Environmental Development Commission, also has set goals for preserving the natural environment of the existing stream system.

Staff members from Lynnwood, Mountlake Terrace, Snohomish County and King County have reviewed the preliminary alternative plans for drainage developed by this RIBCO study for Swamp Creek.

ALTERNATIVE PLANS FOR PROPOSED DRAINAGE CONTROL

The existing drainage system of Swamp Creek Sub-Basin as described by local agencies was evaluated by computer simulation applying the region's 10-year storm to the year 2000 land use. Drainage problems thus identified were analyzed and possible solutions provided in development of alternative plans for drainage control as described below.

ALTERNATIVE PLAN I

General Concept

The general concept of Alternative Plan I is channelization of Swamp and Scribber Creeks to relieve overbank flooding. Culverts and streambank protection would be provided where considered necessary.

Major Features

To accommodate the 2000 Comprehensive Land Use Plan, almost the entire length of Swamp and Scribber Creeks would require channel enlargement, streambank protection or both. Most existing culverts and bridges in the upper watershed would need replacement. Under the 2000 Corridor

Plan, a few of the upper channels would not need enlargement, due to lower runoff reflecting different land use, and channel enlargement where required, would be of different dimension.

Cost

The cost for Alternative Plan I, under the Comprehensive Land Use Plan, is estimated to be $10,600,000. The cost for Alternative Plan I, under the Corridor Land Use Plan, is estimated to be $8,200,000.

ALTERNATIVE PLAN II

General Concept

Alternative Plan II relies upon runoff control from all future development within the Swamp Creek Sub-Basin, and attenuation of peak flows, where feasible, by construction of holding ponds. Flood-plain zoning would be enacted where necessary. This plan would be identical for both future land use plans.

Major Features

The most significant feature of this alternative is on-site runoff control for all future development. Runoff would be limited to an increase of 25% above existing conditions. Since runoff control would be provided for all future development based upon existing conditions, future land-use plans would not affect the creek system directly. Different land-use patterns would dictate the quantity of on-site detention that would be necessary.

Two major holding ponds are included in this alternative. The first is located at the Swamp Creek Interchange. This will substantially reduce downstream flows. A holding pond below Lynnwood on Scribber Creek also is proposed. This would reduce flows in the lower portion of Scribber Creek. Stickney Lake and Martha Lake also are used to attenuate downstream flows. No major modifications of the natural conditions are suggested.

Some channelization and streambank protection would be required because of existing conditions that cannot be accommodated by diversion or flood-plain zoning.

Cost

The cost of Alternative Plan II is estimated to be $5,200,000.

PEAK FLOW COMPARISONS

The following table indicates existing and probable future stream flows under the alternative drainage and land-use plans.

COMPARISON OF 10 YEAR PEAK FLOWS
(Cubic Feet per Second)

Location	Comprehensive Land Use: Existing Facilities*	Comprehensive Land Use: Alternative Plan I	Comp. & Corr. Land Use: Alternative Plan II	Corridor Land Use: Alternative Plan I
Swamp Creek Interchange	125	1025	425	725
Mouth of Martha Lake Outlet	225	290	180	330
Scribber Creek at I-5	275	550	475	500
Mouth of Scribber Creek	650	1100	575	1075
Confluence of Swamp and Scribber Creek	900	1975	925	1750
Mouth of Swamp Creek	450	2100	1050	2000

*NOTE flows constricted by upstream flooding.

ENVIRONMENTAL ASSESSMENT OF ALTERNATIVE PLANS

Field inspections were made of the suggested alternatives for this sub-basin. This process was followed throughout the RIBCO Study in developing alternative plans for the various regional sub-basins. The inspections were based on the alternative-evaluation procedure which identified 34 unique criteria grouped in general categories as follows: 1) Effectiveness, 2) Human Values, 3) Environmental Factors, 4) Implementation, and 5) Resource Requirements.

Various structural elements were checked against the appropriate criteria, and various non-structural elements were reviewed for their relationship to existing and probable future developments. The criteria-rating total for Alternative Plan I under the Comprehensive Land Use Plan, which employs channelization, streambank protection and enlarged conduit, was a minus 34 on a scale ranging from a possible positive total of 108 to a negative total of 108. A total-evaluation rating for Alternative Plan I, under the year 2000 Corridor Land Use Plan, which also employs channelization, streambank protection and enlarged conduit, was also a negative 34. No discernable difference exists in the overall impact of the two Alternative Plan I solutions. The total evaluation rating for Alternative Plan II, which applies to both the year 2000 Corridor and Comprehensive Land Use Plans, and which employs storage and flood

plain zoning in addition to channelization, streambank protection and some enlarged conduit, was a positive 3.

All three alternatives are judged to be about equal as to effectiveness for providing runoff control. Alternative Plan II, because of the assumed runoff control from new development, does have a slight edge due to its probable limitation of erosion and sedimentation. All three alternatives are judged to be equal in human values, although none of them rate in the positive range for this category. Alternative Plan II clearly offers more environmental protection and consideration and is the only alternative plan of the three which registered a positive rating for this category. Preservation of future fisheries potential, under all alternative plans, will require extremely sensitive design solutions for portions of the creek needing streambank protection and channelization. All three plans are considered to be equally difficult to implement and all three plans have relatively significant resource requirements.

Alternative Plan II does contain two critical elements. The suggested use of storage ponds and the designation of certain flood-plain zones, should be implemented as an early organized effort if these solutions are to be part of the chosen alternative. Any development which occurs within the flood-plain areas would force the use of some form of structural treatment, such as channelization or streambank protection. Also, development of the suggested storage sites would eliminate their use in runoff control, and would force the use of more structural solution in the Swamp Creek sub-basin. This issue should be brought to the attention of all affected citizens and their local agencies. It also should be understood that this alternative, because it suggests flood plain zoning, would effectively remove the portions of the sub-basin so designated from any future intensive land uses typical of urbanized areas.

CONCLUSIONS

Alternative Plan II is clearly superior to Alternative Plan I as it provides the best control during high-flow conditions and also has the additional feature of assuring year-around stream flows and control of water quality. The agencies involved in managing the Swamp Creek Sub-Basin should establish an effective agreement on a master drainage plan for the entire sub-basin, incorporating the conditions of Alternative Plan II. These agencies should then move to implement and enforce the required flood-plain zoning within their own jurisdictions, and obtain, through acquisition if necessary, the required storage areas.

At issue is which agency or agencies will have jurisdiction and responsibility for control of urban drainage and related flood damage and problems. There is also the issue of the use or extent of use, of land use and zoning control methods by and between the various agencies.

Snohomish County should have primary responsibility for control of drainage and flood damage within the Swamp Creek Sub-Basin and the City of Lynnwood and King County should exercise control of future development, including any necessary flood-plain zoning, within their respective boundaries.

RUNOFF QUALITY SUMMARY
SWAMP CREEK

BASED UPON A 10-YEAR STORM PRECEDED BY 15 DAYS WITH LITTLE OR NO RAINFALL#

LOCATION	ALTERNATIVE PLAN	PEAK FLOW (cfs)	CONCENTRATION AT PEAK FLOW*				
			BOD	TOTAL COLIFORM	NH_3	$NO_2 + NO_3$	PO_4
Mouth	2000 Comprehensive Land Use						
	I	2100	14	2.5×10^5	.4	1.1	.4
	II	1050	18	3.4×10^5	.6	1.4	.4
Mouth	2000 Corridor Land Use						
	I	2000	14	4.7×10^5	.5	1.1	.3
	II	1050	18	3.4×10^5	.6	1.4	.4

Less than a total of 0.5 inches of rainfall in any one day.
* Concentrations in mg/liter except total coliform which is in MPN/100 ml.

EVALUATION MATRIX

SWAMP CREEK

ALTER-NATIVES	SUB TOTAL	EFFECTIVENESS								SUB TOTAL	HUMAN VALUES							SUB TOTAL	ENVIRONMENTAL FACTORS									SUB TOTAL	IMPLEMENTATION						SUB TOTAL	RESOURCE REQUIREMENTS				RATING TOTAL
		Use of existing facilities	System reliability	System maintainability	System flexibility	Flood damage reduction	Consequences of overcharge	Erosion and sedimentation control	Cost/benefits ranking		Urban quality (aesthetics)	Effect on land use	Displacement of people	Educational value	Community cohesion	Multiple use potential	Public health and safety		High flow conditions	Alteration of natural system	Effects on groundwater	Low flow conditions	Water quality	Construction disruption	Effects on wildlife	Effects on aquatic life	Effects on vegetation		Legislative requirements	Jurisdictional	Land acquisition	Public acceptance	Financing	Effects of no action		Energy	Materials	Land	Capital	
		CRITERIA WEIGHT									CRITERIA WEIGHT								CRITERIA WEIGHT										CRITERIA WEIGHT							CRITERIA WEIGHT				
		1	4	3	2	4	4	4	2		4	2	2	1	3	3	4		4	4	4	4	4	2	4	4	4		4	4	2	4	4	3		3	3	2	2	
I Comp.	-1									-2								-18										-3							-10					-34
I Corr.	-1									-2								-18										-3							-10					-34
II	+5									0								+10										-4							-8					+3

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative I   Sub Basin Swamp Creek - Comprehensive Plan

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
41	Channel	20'	7,300'	1:1	5'	Channel	45' width 5' depth 2:1 side slopes Streambank protection	$683,000
39	Channel	20'	4,500'	2:1	5'	Channel	45' width 5' depth 2:1 side slopes Streambank protection	$517,000
94	Culvert	4.9'	30'	0	3.5'	Replace-ment Culvert	8' x 3.5'	$10,000
24	Channel	10'	2,000'	1:1	4'	Channel	38' width 4' depth 1:1 side slopes	$120,000
23	Culvert	5.6'	30'	0	4'	Replace-ment Culvert	20' x 4'	$21,000
93	Channel	10'	300'	1:1	4'	Channel	38' width 4' depth 1:1 side slopes	$22,000
22	Channel	10'	1,500'	1:1	5'	Channel	22' width 5' depth 2:1 side slopes	$32,000
28	Pipe	36"	3,000'			Parallel Pipe	36"	$198,000
32	Pipe	18"	2,000'			Parallel Pipe	48"	$186,000
18	Channel	10'	2,500'	1:1	4'	Channel	50' width 4' depth 2:1 side slopes Streambank protection	$215,000
17	Channel	15'	3,500'	1.5:1	5'	Channel	30' width 5' depth 2:1 side slopes Streambank protection	$273,000
15	Channel	25'	900'	1:1	4'	Channel	95' width 4' depth 2:1 side slopes Streambank protection	$174,000
13	Channel	15'	3,000'	1.25:1	4'	Channel	100' width 4' depth 2:1 side slopes Streambank protection	$402,000
11	Channel	20'	1,800'	1.25:1	5'	Channel	80' width 5' depth 2:1 side slopes Streambank protection	$355,000
48	Culvert	5.6'	50'	0	4'	Replace-ment Culvert	35' x 4'	$55,000
45	Channel	15'	4,000'	2:1	5'	Channel	35' width 5' depth 2:1 side slopes Streambank protection	$323,000
87	Pipe	36"	30'			Parallel Pipe	36"	$13,000

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative I   Sub-Basin Swamp Creek - Comprehensive Plan

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
76	Channel	5'	5,000'	1:1	3'	Channel	8' width 3' depth 1:1 side slopes	$26,000
75	Channel	10'	2,300'	1:1	4'	Channel	10' width 4' depth 2:1 side slopes	$39,000
70	Channel	10'	1,800'	1:1	4'	Channel	70' width 4' depth 2:1 side slopes	$231,000
69	Channel	10'	2,500'	1:1	4'	Channel	70' width 4' depth 2:1 side slopes	$321,000
68	Culvert	5.6'	30'	0	4'	Culvert	25' x 4'	$25,000
67	Channel	10'	2,000'	1:1	4'	Channel	60' width 4' depth 2:1 side slopes	$219,000
62	Channel	10'	2,500'	1:1	4'	Channel	25' width 4' depth 2:1 side slopes	$102,000
82	Channel	5'	6,000'	1:1	3'	Channel	12' width 3' depth 2:1 side slopes	$122,000
83	Channel	5'	7,000'	1:1	3'	Channel	5' width 3' depth 2:1 side slopes	$58,000
80	Culvert	24"	30'			Replacement Culvert	7' x 4'	$10,000
79	Channel	10'	3,500'	1:1	4'	Channel	12' width 4' depth 2:1 side slopes Streambank protection	$216,000
78	Culvert	2.8'	30'	0	2'	Replacement Culvert	27' x 4'	$26,000
60	Culvert	10'	30'	0	3'	Replacement Culvert	10' x 6'	$14,000
59	Channel	17'	3,000'	1:1	6'	Channel	22' width 6' depth 2:1 side slopes Streambank protection	$300,000
54	Culvert	7.5'	30'	0	3'	Bridge	45' width 3' depth Vertical walls	$42,000
53	Channel	10'	5,000'	2.5:1	4'	Channel	80' width 4' depth 2:1 side slopes	$342,000
50	Culvert	10'	30'	0	6'	Replacement Culvert	15' x 6'	$17,000

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative I Sub Basin Swamp Creek - Comprehensive Plan

ELEMENT NUMBER	EXISTING FACILITIES TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	PROPOSED FACILITIES TYPE		ESTIMATED CAPITAL COST
49	Channel	14'	5,000'	2:1	5'	Channel	65' width 5' depth 2:1 side slopes	$314,000
9	Channel	20'	6,000'	1:1	5'	Channel	70' width 5' depth 2:1 side slopes Streambank protection	$1,054,000
5	Channel	5'	1,600'	1.5:1	6'	Channel	125' width 6' depth 1:1 side slopes	$441,000
3	Channel	30'	3,700'	2.5:1	4'	Channel	175' width 4' depth 1:1 side slopes Streambank protection	$990,000
1	Channel	33'	2,000'	1.5:1	7'	Flood plain zoning	Sammamish River flood plain	-0-
61	Channel	15'	2,500'	1:1	6'	Channel	Streambank protection	$106,000
86	Channel	10'	7,000'	2:1	5'	Channel	Streambank protection	$393,000
85	Channel	15'	3,500'	2:1	5'	Channel	Streambank protection	$196,000
21	Channel	10'	300'	1:1	5'	Channel	Streambank protection	$11,000
19	Channel	10'	3,300'	1:1	5'	Channel	Streambank protection	$117,000
30	Channel	10'	6,000'	1:1	5'	Channel	Streambank protection	$213,000
33	Channel	10'	8,000'	1:1	5'	Channel	Streambank protection	$283,000
7	Channel	19'	2,700'	.75:1	10'	Channel	Streambank protection	$172,000
4	Channel	3'	9,500'	1.5:1	5'	Channel	Streambank protection	$435,000
1	Channel	33'	2,000'	1.5:1	7'	Channel	Streambank protection	$128,000

The Estimated Capital Cost for each element includes Contractor profit, engineering, legal and contingencies. In addition, land purchase and severance costs are included where land is required. All costs are based upon June 1973 prices.

Total Estimated Capital Cost: $10,562,000
Round To: $10,600,000

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative I Sub-Basin Swamp Creek - Corridor Plan

ELEMENT NUMBER	EXISTING FACILITIES: TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	PROPOSED FACILITIES: TYPE		ESTIMATED CAPITAL COST
70	Channel	10'	1,800'	1:1	4'	Channel	25' width 4' depth 2:1 side slopes	$60,000
69	Channel	10'	2,500'	1:1	4'	Channel	25' width 4' depth 2:1 side slopes	$84,000
67	Channel	10'	2,000'	1:1	4'	Channel	20' width 4' depth 2:1 side slopes	$63,000
62	Channel	10'	2,500'	1:1	4'	Channel	10' width 4' depth 2:1 side slopes	$30,000
82	Channel	5'	6,000'	1:1	3'	Channel	5' width 3' depth 2:1 side slopes	$50,000
80	Culvert	24"	30'			Parallel Culvert	66"	$15,000
78	Culvert	2.8'	30'	0	2'	Replacement Culvert	15' x 4'	$15,000
59	Channel	17'	3,000'	1:1	6'	Channel	22' width 6' depth 2:1 side slopes Streambank protection	$300,000
54	Culvert	7.5'	30'	0	3'	Replacement Culvert	10' x 5'	$13,000
53	Channel	10'	5,000'	2.5:1	4'	Channel	50' width 4' depth 2:1 side slopes	$191,000
49	Channel	14'	5,000'	2:1	5'	Channel	45' width 4' depth 2:1 side slopes	$119,000
48	Culvert	5.6'	50'	0	4'	Replacement Culvert	25' x 4'	$40,000
87	Culvert	36"	30'			Parallel Culvert	42"	$9,000
84	Culvert	60"	30'			Parallel Culvert	18"	$4,000
41	Channel	20'	7,300'	1:1	5'	Channel	50' width 5' depth 2:1 side slopes Streambank protection	$728,000
94	Culvert	4.9'	30'	0	3.5'	Replacement Culvert	8' x 3.5'	$10,000
24	Channel	10'	2,000'	1:1	4'	Channel	35' width 4' depth 2:1 side slopes	$131,000

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative I Sub-Basin Swamp Creek - Corridor Plan

	EXISTING FACILITIES					PROPOSED FACILITIES		
ELEMENT NUMBER	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
23	Culvert	5.6'	30'	0	4'	Replacement Culvert	18 ' x 4'	$19,000
32	Pipe	18"	2,000'			Parallel Pipe	42"	$158,000
18	Channel	10'	2,500'	1:1	4'	Channel	40' width 4' depth 2:1 side slopes Streambank protection	$200,000
17	Channel	15'	3,500'	1.5:1	5'	Channel	30' width 5' depth 2:1 side slopes Streambank protection	$273,000
15	Channel	25'	900'	1:1	4'	Channel	75' width 4' depth 2:1 side slopes Streambank protection	$138,000
13	Channel	15'	3,000'	1:1	4'	Channel	85' width 4' depth 2:1 side slopes Streambank protection	$322,000
11	Channel	20'	1,800'	1:1	5'	Channel	60' width 5' depth 2:1 side slopes Streambank protection	$229,000
9	Channel	20'	6,000'	1:1	5'	Channel	60' width 5' depth 2:1 side slopes Streambank protection	$927,000
5	Channel	5'	1,600'	1.5:1	6'	Channel	110' width 6' depth 2:1 side slopes	$417,000
3	Channel	30'	3,700'	2.5:1	4'	Channel	160' width 4' depth 2:1 side slopes Streambank protection	$882,000
1	Channel	33'	2,000'	1.5:1	7'	Flood plain zone	Sammamish River flood plain Streambank protection	$128,000
61	Channel	15'	2,500'	1:1	6'	Channel	Streambank protection	$106,000
45	Channel	15'	4,000'	2:1	5'	Channel	Streambank protection	$224,000
86	Channel	10'	7,000'	2:1	5'	Channel	Streambank protection	$393,000
85	Channel	15'	3,500'	2:1	5'	Channel	Streambank protection	$196,000
93	Channel	10'	300'	1:1	4'	Channel	30' width 4' depth 2:1 side slopes	$25,000
22	Channel	10'	1,500'	1:1	5'	Channel	25' width 5' depth 2:1 side slopes	$38,000

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative I Sub-Basin Swamp Creek - Corridor Plan

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
28	Pipe	36"	3,000'			Parallel Pipe	36"	$198,000
39	Channel	20'	4,500'	2:1	5'	Channel	Streambank protection	$242,000
21	Channel	10'	300'	1:1	5'	Channel	Streambank protection	$11,000
19	Channel	10'	3,300'	1:1	5'	Channel	Streambank protection	$117,000
30	Channel	10'	6,000'	1:1	5'	Channel	Streambank protection	$213,000
33	Channel	10'	8,000'	1:1	5'	Channel	Streambank protection	$283,000
7	Channel	19'	2,700'	.75:1	10'	Channel	Streambank protection	$172,000
4	Channel	3'	9,500'	1.5:1	5'	Channel	Streambank protection	$435,000

The Estimated Capital Cost for each element includes Contractor profit, engineering, legal and contingencies. In addition, land purchase and severance costs are included where land is required. All costs are based upon June 1973 prices.

Total Estimated Capital Cost: $8,208,000

Round To: $8,200,000

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative II Sub-Basin Swamp Creek - Comprehensive and Corridor Plans

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
70	Channel	10'	1,800'	1:1	4'	Channel	30' width 4' depth 1:1 side slopes	$70,000
69	Channel	10'	2,500'	1:1	4'	Channel	30' width 4' depth 1:1 side slopes	$96,000
67	Channel	10'	2,000'	1:1	4'	Channel	25' width 4' depth 1:1 side slopes	$58,000
80	Culvert	24"	30'			Replacement Culvert	54"	$12,000
78	Culvert	2.8'	30'	0	2'	Replacement Culvert	8' x 4'	$10,000
54	Culvert	7.5'	30'	0	3'	Replacement Culvert	10' x 4'	$12,000
53	Channel	10'	5,000'	2.5:1	4'	Channel	Flood plain zone	-0-
48	None					Holding Pond	21 AF	$145,000
89	Lake					Outlet Control	Martha Lake	$8,000
94	Culvert	4.9'	30'	0	3.5'	Parallel Culvert	60"	$13,000
24	Channel	10'	2,000'	1:1	4'	Channel	35' width 4' depth 1:1 side slopes	$107,000
23	Culvert	5.6'	30'	0	4'	Replacement Culvert	16' x 4'	$18,000
22	Channel	10'	1,500'	1:1	5'	Channel	20' width 5' depth 2:1 side slopes	$29,000
28	Pipe	36"	3,000'			Parallel Pipe	48"	$198,000
19	None					Holding Pond	31 AF	$139,000
32	Pipe	18"	2,000'			Parallel Pipe	33"	$120,000
18	Channel	10'	2,500'	1:1	4'	Channel	Flood plain zone	-0-

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative II Sub Basin Swamp Creek - Comprehensive and Corridor Plans

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
13	Channel	15'	3,000'	1:1	4'	Channel	45' width 4' depth 1:1 side slopes Streambank protection	$173,000
5	Channel	5'	1,600'	1.5:1	6'	Channel	75' width 6' depth 1:1 side slopes	$250,000
3	Channel	30'	3,700'	2.5:1	4'	Channel	85' width 4' depth 1:1 side slopes Streambank protection	$404,000
1	Channel	33'	2,000'	1.5:1	7'	Channel	Flood plain zone	-0-
86	Channel	10'	7,000'	2:1	5'	Channel	Streambank protection	$393,000
85	Channel	15'	3,500'	2:1	5'	Channel	Streambank protection	$196,000
61	Channel	15'	2,500'	1:1	6'	Channel	Streambank protection	$106,000
59	Channel	17'	3,000'	1:1	6'	Channel	Streambank protection	$127,000
45	Channel	15'	4,000'	2:1	5'	Channel	Streambank protection	$224,000
41	Channel	20'	7,300'	1:1	5'	Channel	Streambank protection	$258,000
39	Channel	20'	4,500'	2:1	5'	Channel	Streambank protection	$242,000
33	Channel	10'	8,000'	1:1	5'	Channel	Streambank protection	$283,000
30	Channel	10'	6,000'	1:1	5'	Channel	Streambank protection	$212,000
21	Channel	10'	300'	1:1	5'	Channel	Streambank protection	$11,000
18	Channel	10'	2,500'	1:1	4'	Channel	Streambank protection	$71,000
17	Channel	15'	3,500'	1.5:1	5'	Channel	Streambank protection	$160,000
15	Channel	25'	900'	1:1	4'	Channel	Streambank protection	$25,000

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

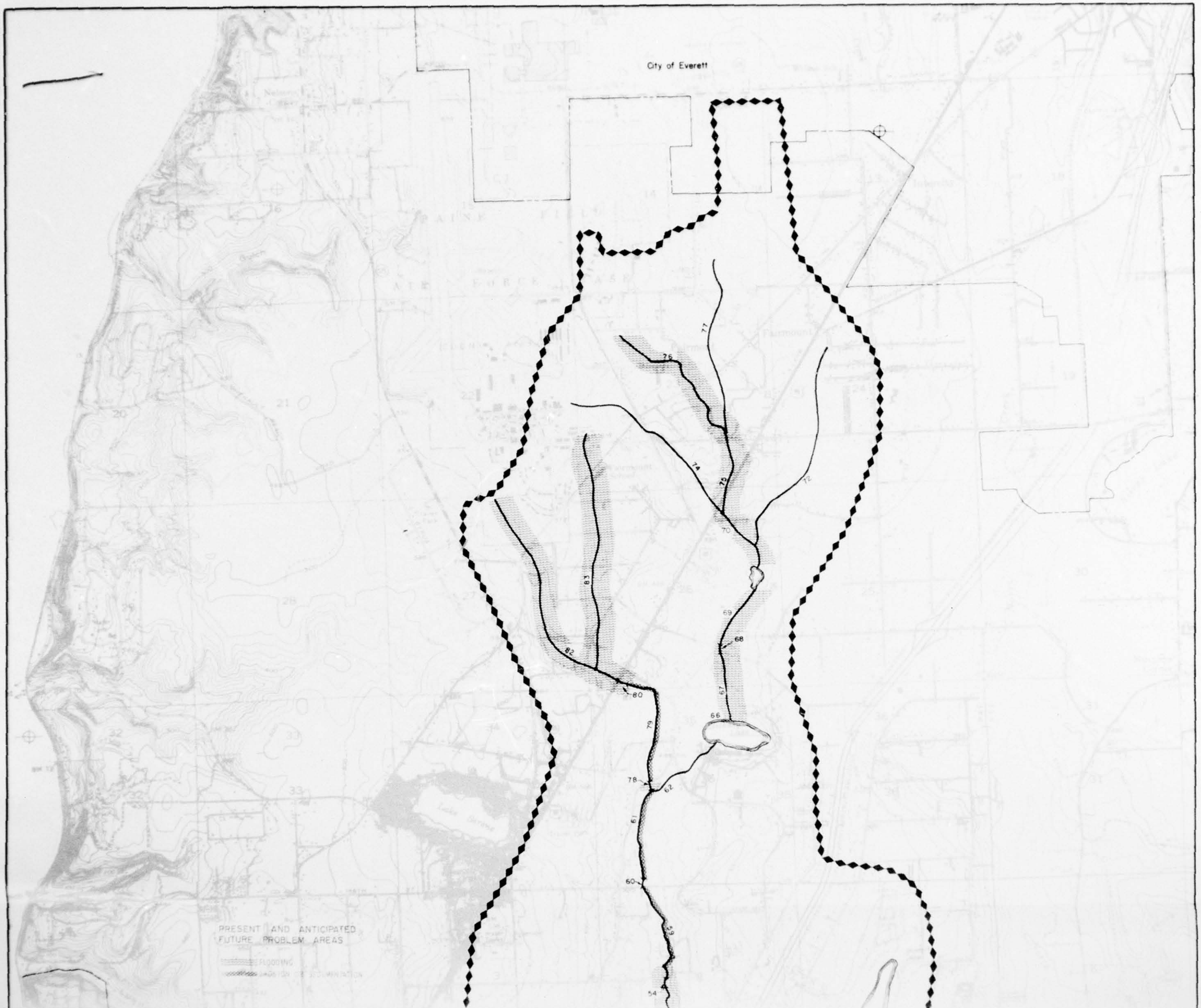
Alternative II Sub-Basin Swamp Creek - Comprehensive and Corridor Plans

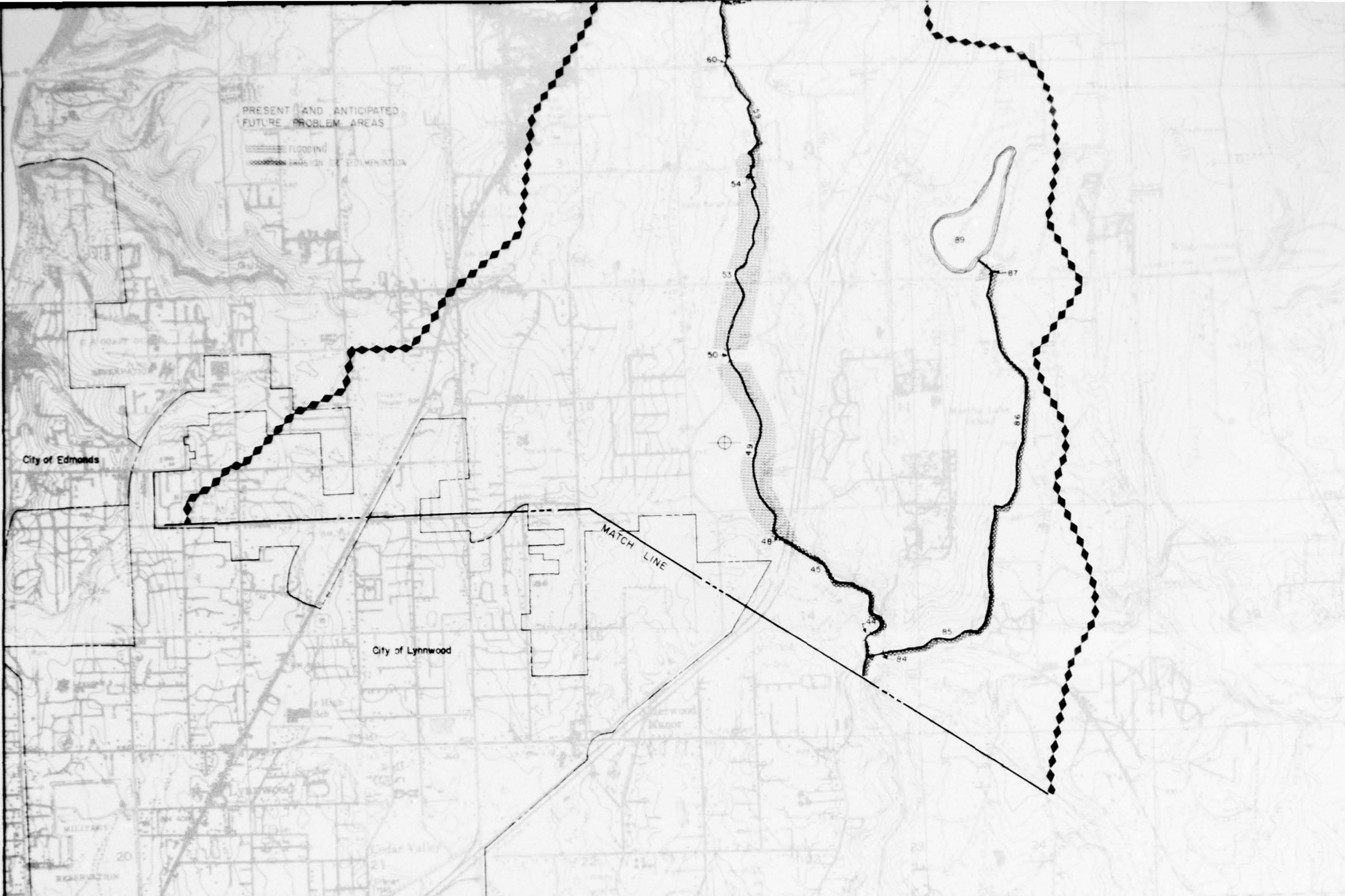
ELEMENT NUMBER	EXISTING FACILITIES: TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	PROPOSED FACILITIES: TYPE		ESTIMATED CAPITAL COST
11	Channel	20'	1,800'	1:1	5'	Channel	Streambank protection	$73,000
9	Channel	20'	6,000'	1:1	5'	Channel	Streambank protection	$242,000
7	Channel	19'	2,700'	.75:1	10'	Channel	Streambank protection	$172,000
4	Channel	3'	9,500'	1.5:1	5'	Channel	Streambank protection	$435,000
1	Channel	33'	2,000'	1.5:1	7'	Channel	Streambank protection	$128,000

The Estimated Capital Cost for each element includes Contractor profit, engineering, legal and contingencies. In addition, land purchase and severance costs are included where land is required. All costs are based upon June 1973 prices.

Total Estimated Capital Cost: $5,220,000

Round To: $5,200,000


City of Everett
PAINE FIELD
AIR FORCE BASE
Lake Serene
PRESENT AND ANTICIPATED
FUTURE PROBLEM AREAS
FLOODING



LEGEND

SUB-BASIN BOUNDARY
EXISTING CHANNEL
EXISTING CONDUIT
MANHOLE, INLET, OR JUNCTION
CHANNEL OR CONDUIT DESIG 5
CITY LIMITS
COUNTY (METRO) BOUNDARY
LEVEE
CULVERT
HOLDING POND OR LAKE

N

1/2 1/4 0 1
MILES
1000 500 0 4000
FEET

NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

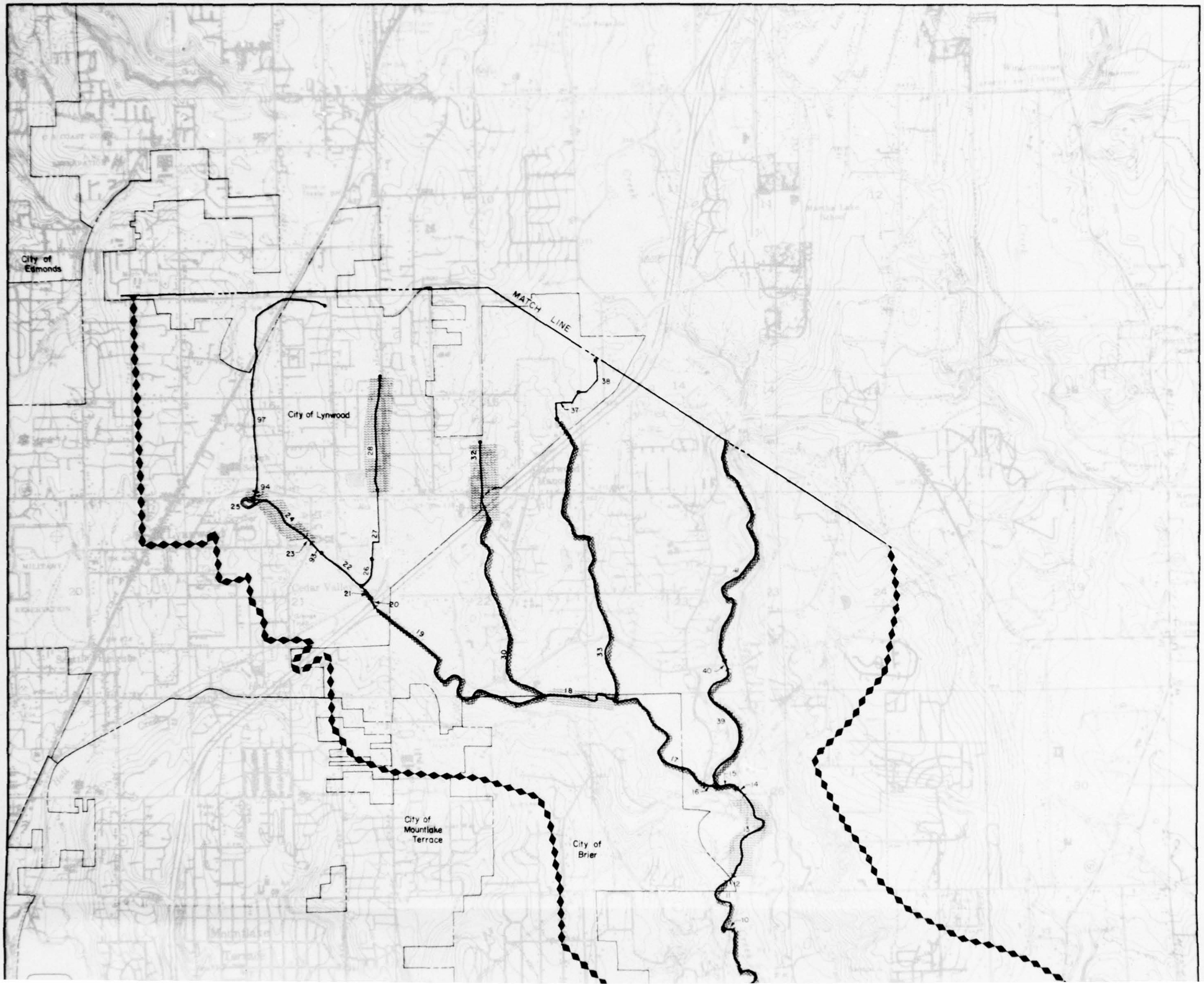
SWAMP CREEK

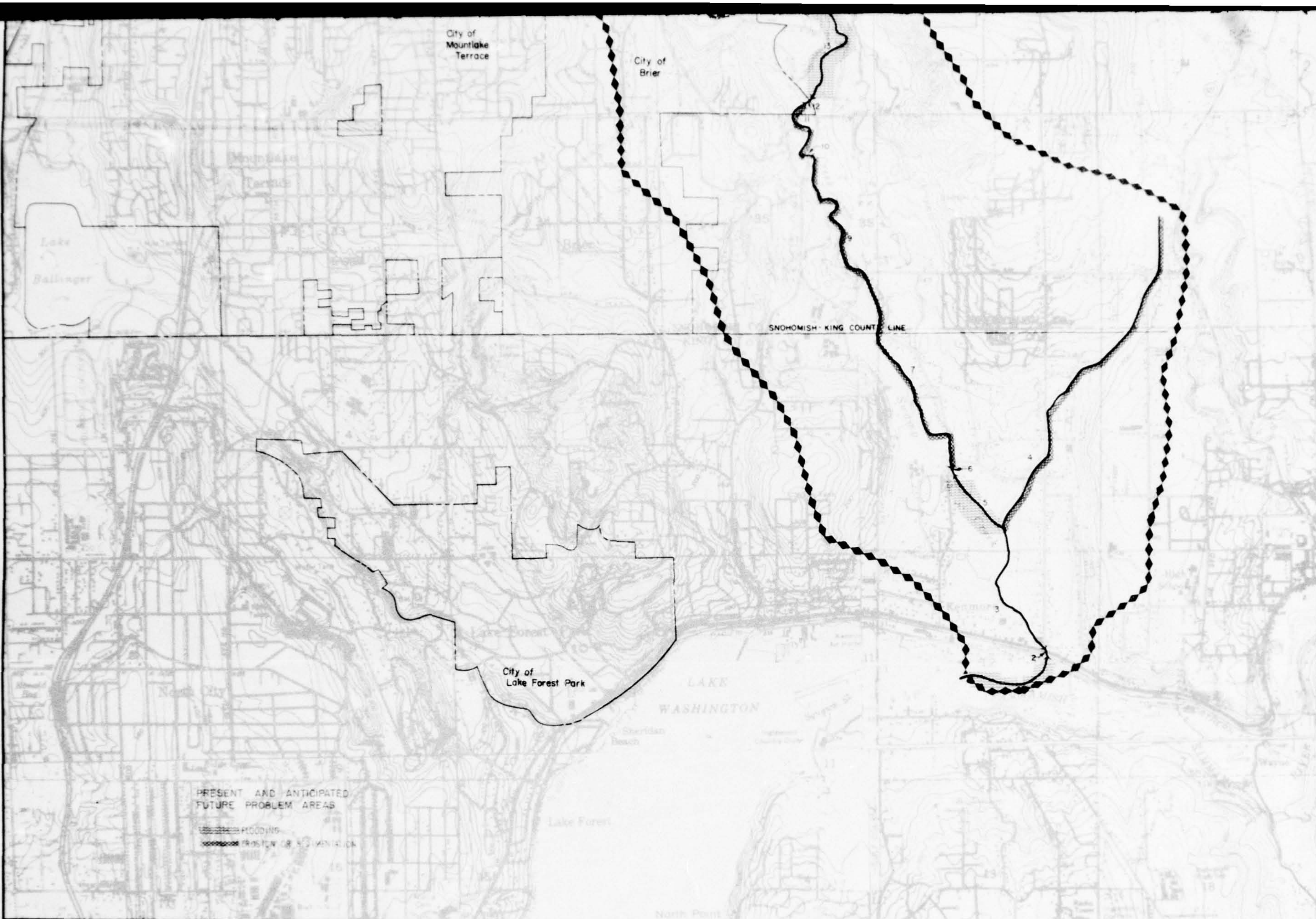
PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

KRAMER, CHIN AND MAYO, INC.
WATER RESOURCES ENGINEERS, INC.
YODER, TROTTER, ORLOB & ASSOCIATES

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO. E-26-1-161 SHEET 1 OF 2


City of Edmonds
MATCH LINE
City of Lynwood
City of Mountlake Terrace
City of Brier



LEGEND

SUB-BASIN BOUNDARY
EXISTING CHANNEL
EXISTING CONDUIT
MANHOLE, INLET, OR JUNCTION
CHANNEL OR CONDUIT DESIG. 5
CITY LIMITS
COUNTY (METRO) BOUNDARY
LEVEE

CULVERT
HOLDING POND OR LAKE

N

1/2 1/4 0 1
MILES
1000 500 0 4000
FEET

NO.	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

SWAMP CREEK

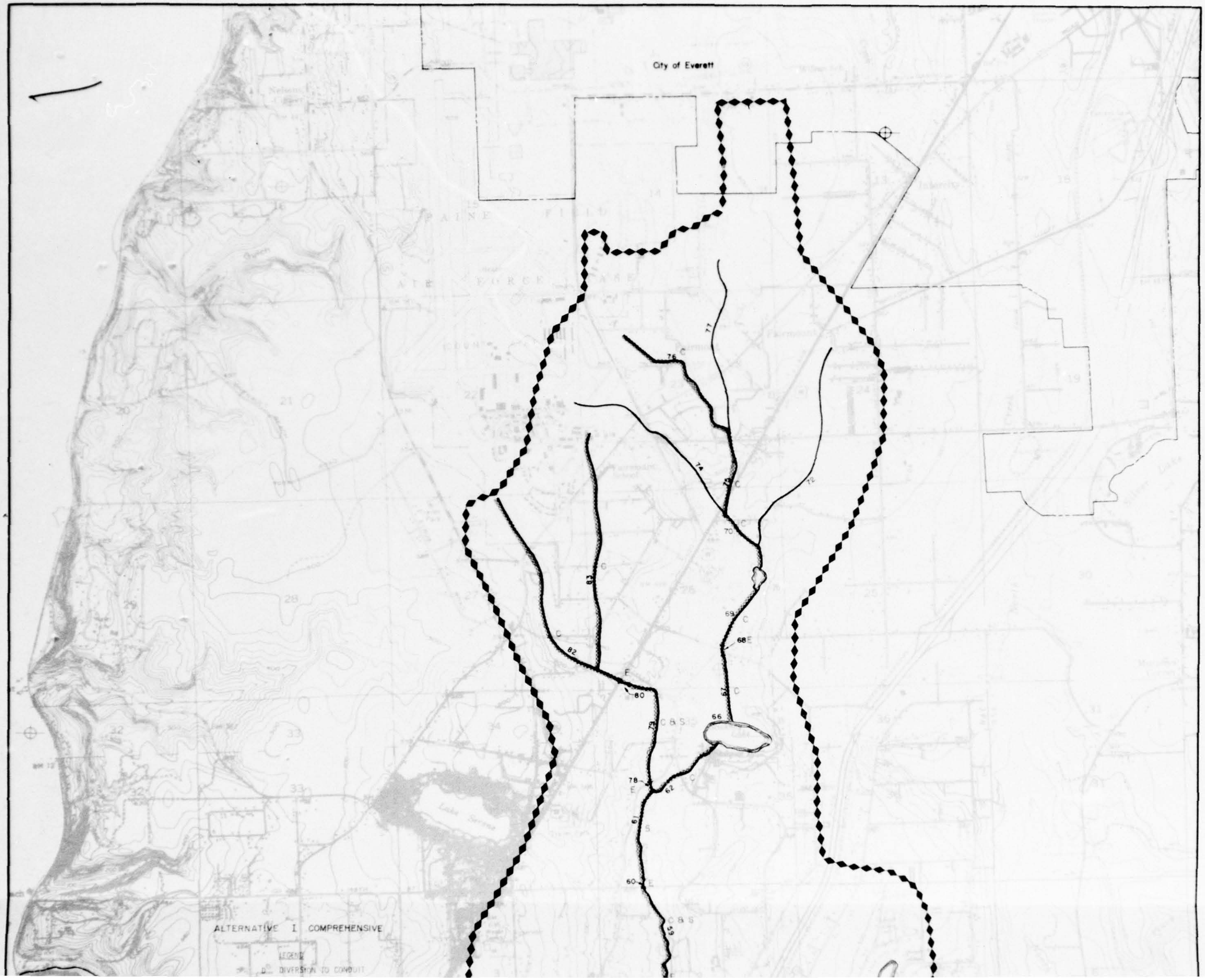
PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

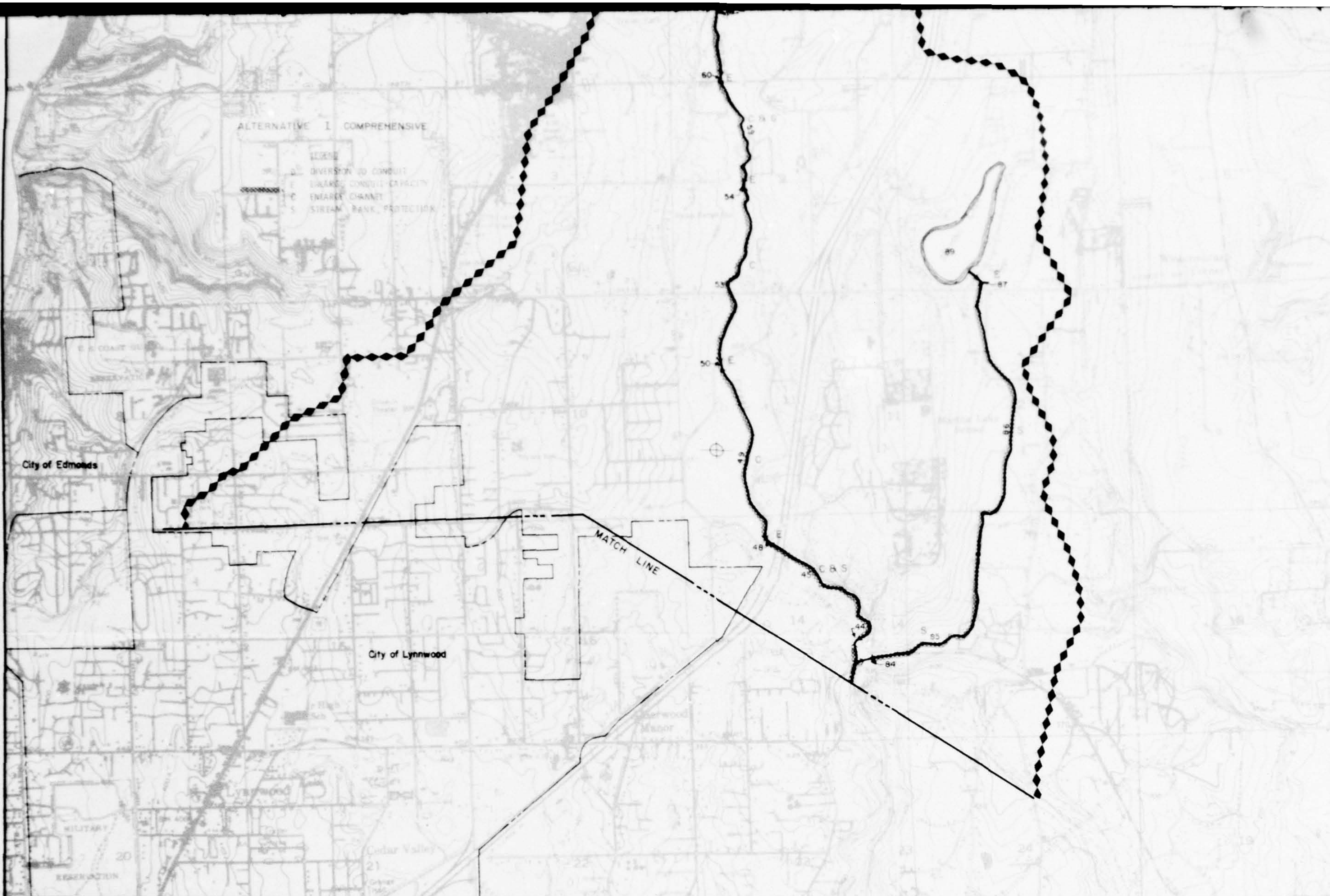
KRAMER, CHIN AND MAYO, INC.
WATER RESOURCES ENGINEERS, INC.
YODER, TROTTER, ORLOB & ASSOCIATES

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO. E-26-1-161 SHEET 2 OF 2

2


City of Everett
PAINE FIELD
AIR FORCE BASE
Lake Serene
ALTERNATIVE I COMPREHENSIVE
LEGEND
DIVERSION TO CONDUIT



LEGEND

SUB-BASIN BOUNDARY
EXISTING CHANNEL
EXISTING CONDUIT
MANHOLE, INLET, OR JUNCTION
CHANNEL OR CONDUIT DESIG. 5
CITY LIMITS
COUNTY (METRO) BOUNDARY
LEVEE

CULVERT
HOLDING POND OR LAKE

N

1/2 1/4 0 1
MILES

1000 500 0 4000
FEET

NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

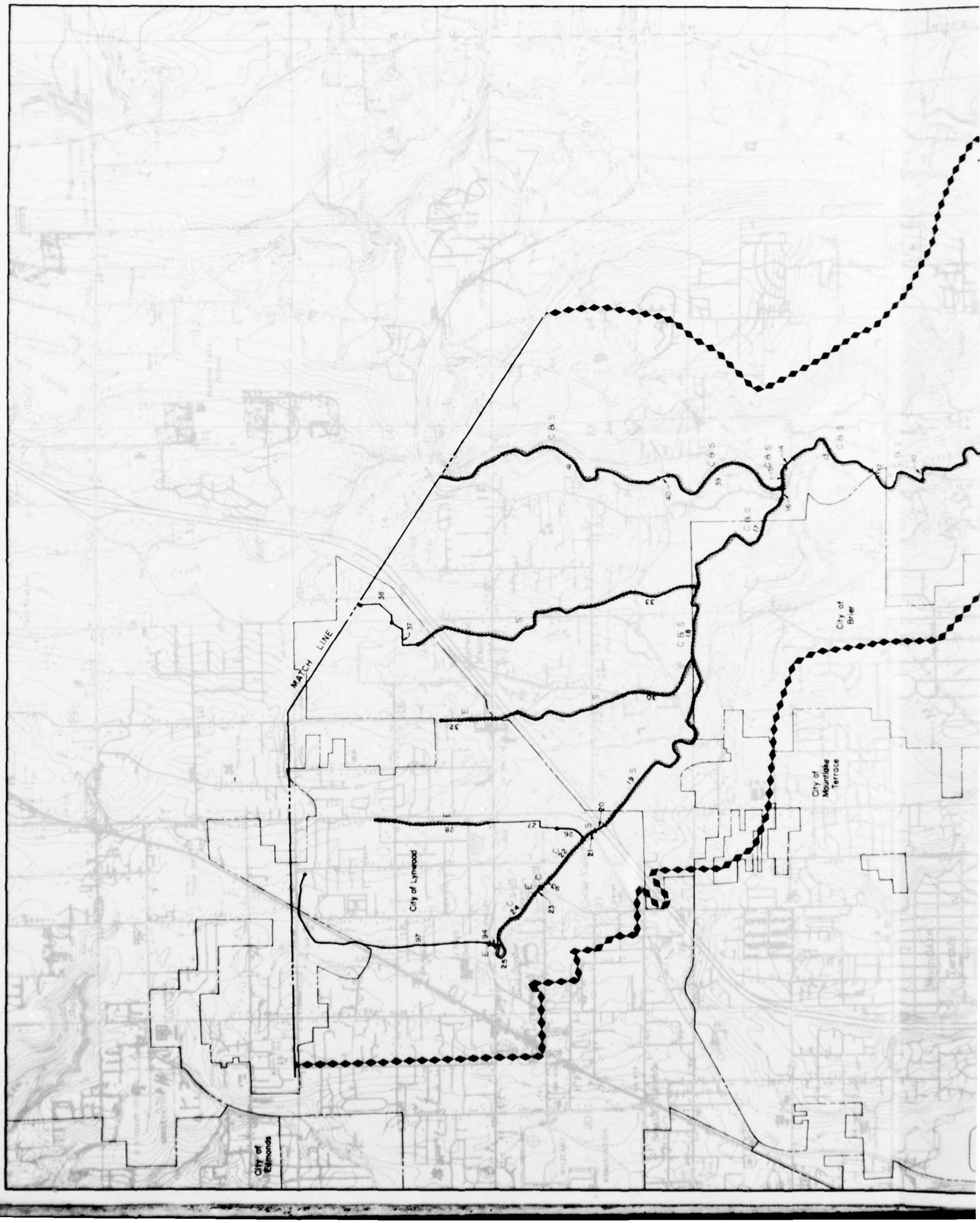
SWAMP CREEK

PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

KRAMER, CHIN AND MAYO, INC
WATER RESOURCES ENGINEERS, INC
YODER, TROTTER, ORLOB & ASSOCIATES

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO E-26-1-161 SHEET 1 OF 2



MATCH LINE
City of Lynwood
City of Brier
City of Mountlake Terrace
City of Edmonds

LEGEND

SUB-BASIN BOUNDARY
EXISTING CHANNEL
EXISTING CONDUIT
MANHOLE, INLET, OR JUNCTION
CHANNEL OR CONDUIT DESIG. — 5
CITY LIMITS
COUNTY (METRO) BOUNDARY
LEVEE

CULVERT
HOLDING POND OR LAKE

N

1/2 1/4 0 1 MILES

1000 500 0 4000 FEET

NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

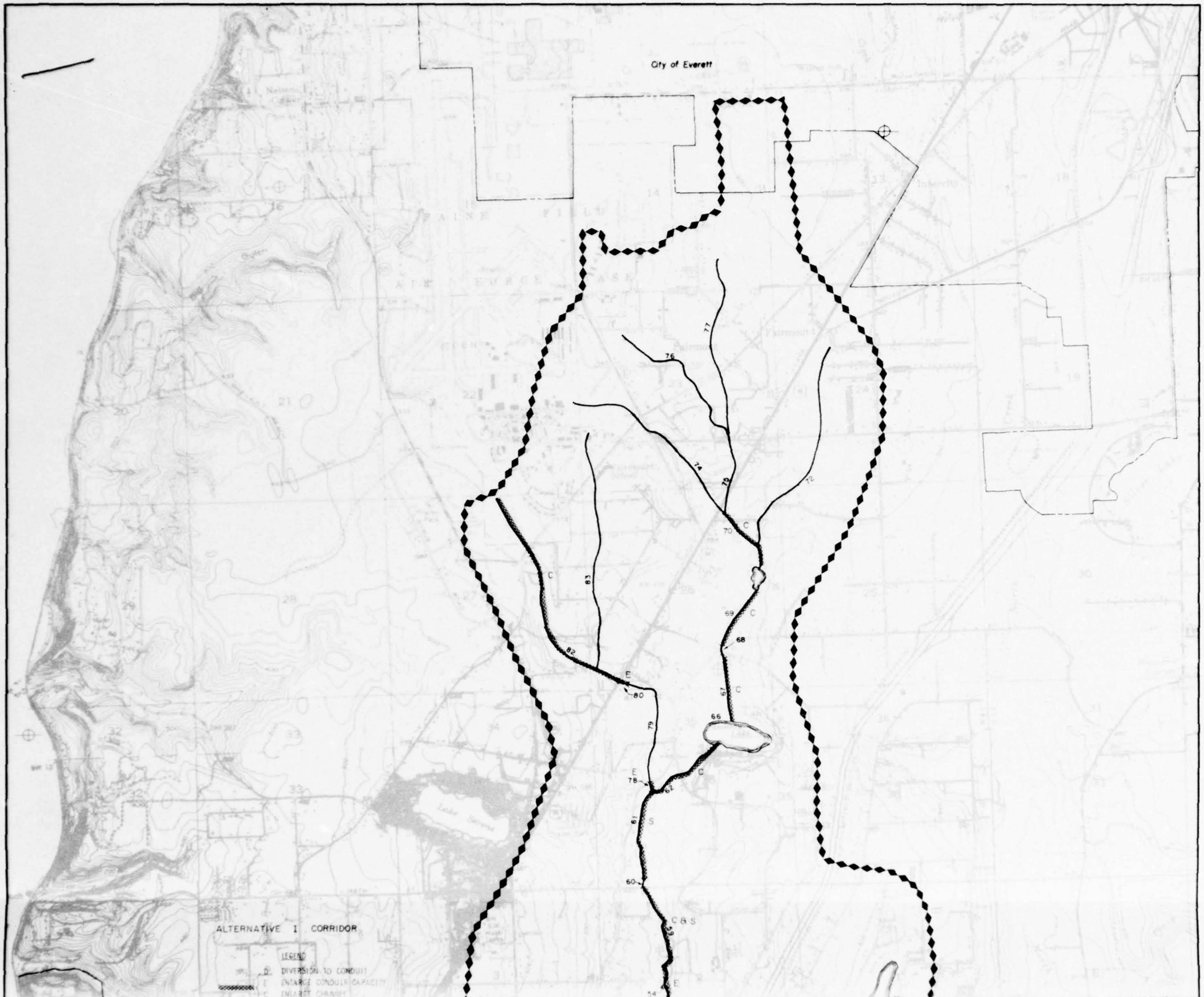
SWAMP CREEK

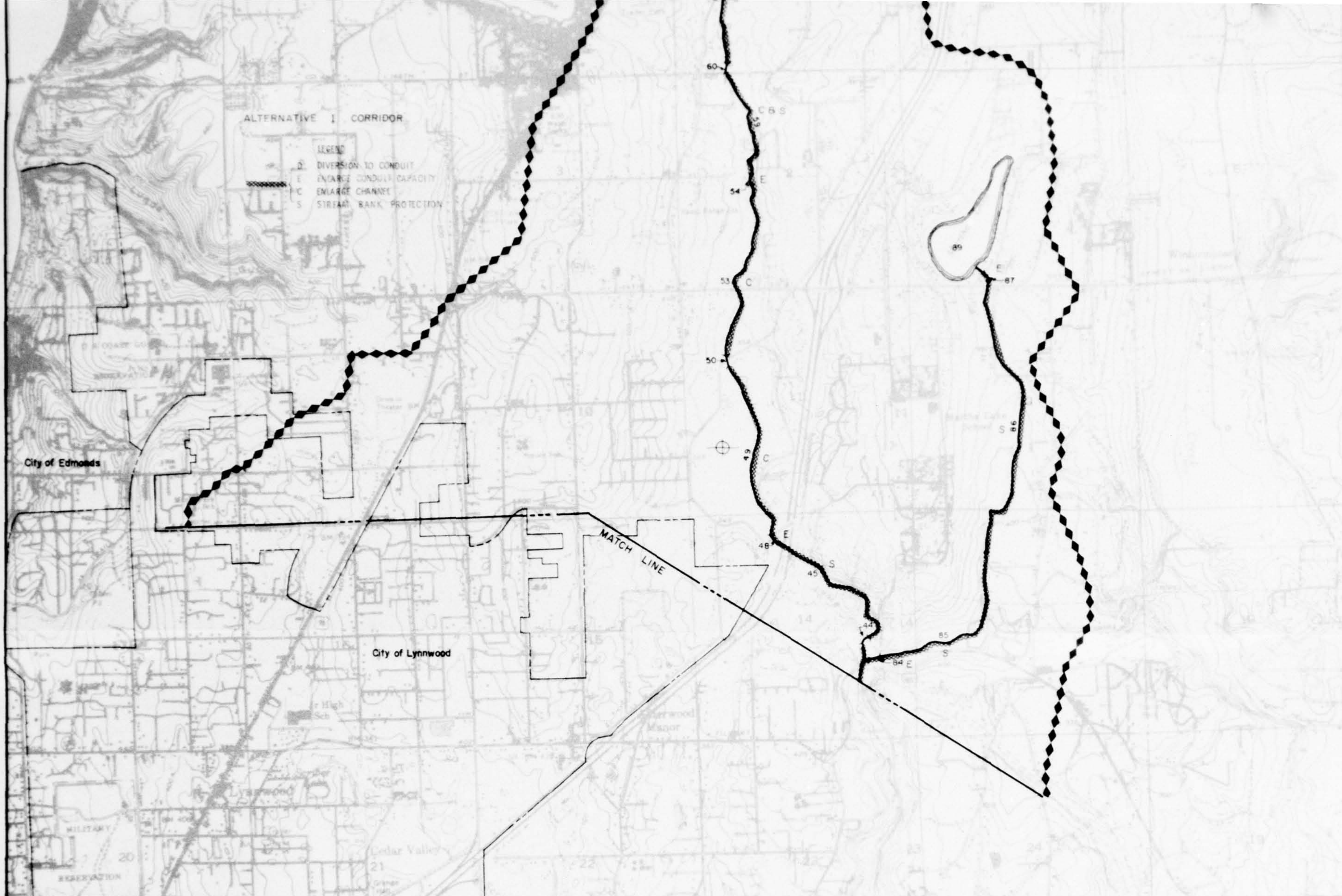
PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

KRAMER, CHIN AND MAYO, INC.
WATER RESOURCES ENGINEERS, INC.
YODER, TROTTER, ORLOB & ASSOCIATES

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO. E-26-1-161 SHEET 2 OF 2


City of Everett
PAINE FIELD
AIR FORCE BASE
Lake Serene
ALTERNATIVE I CORRIDOR
LEGEND
D DIVERSION TO CONDUIT
E ENLARGE CONDUIT CAPACITY
C ENLARGE CHANNEL



LEGEND

SUB-BASIN BOUNDARY
EXISTING CHANNEL
EXISTING CONDUIT
MANHOLE, INLET, OR JUNCTION
CHANNEL OR CONDUIT DESIG. 5
CITY LIMITS
COUNTY (METRO) BOUNDARY
LEVEE

CULVERT
HOLDING POND OR LAKE

N

1/2 1/4 0 1
MILES
1000 500 0 4000
FEET

NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

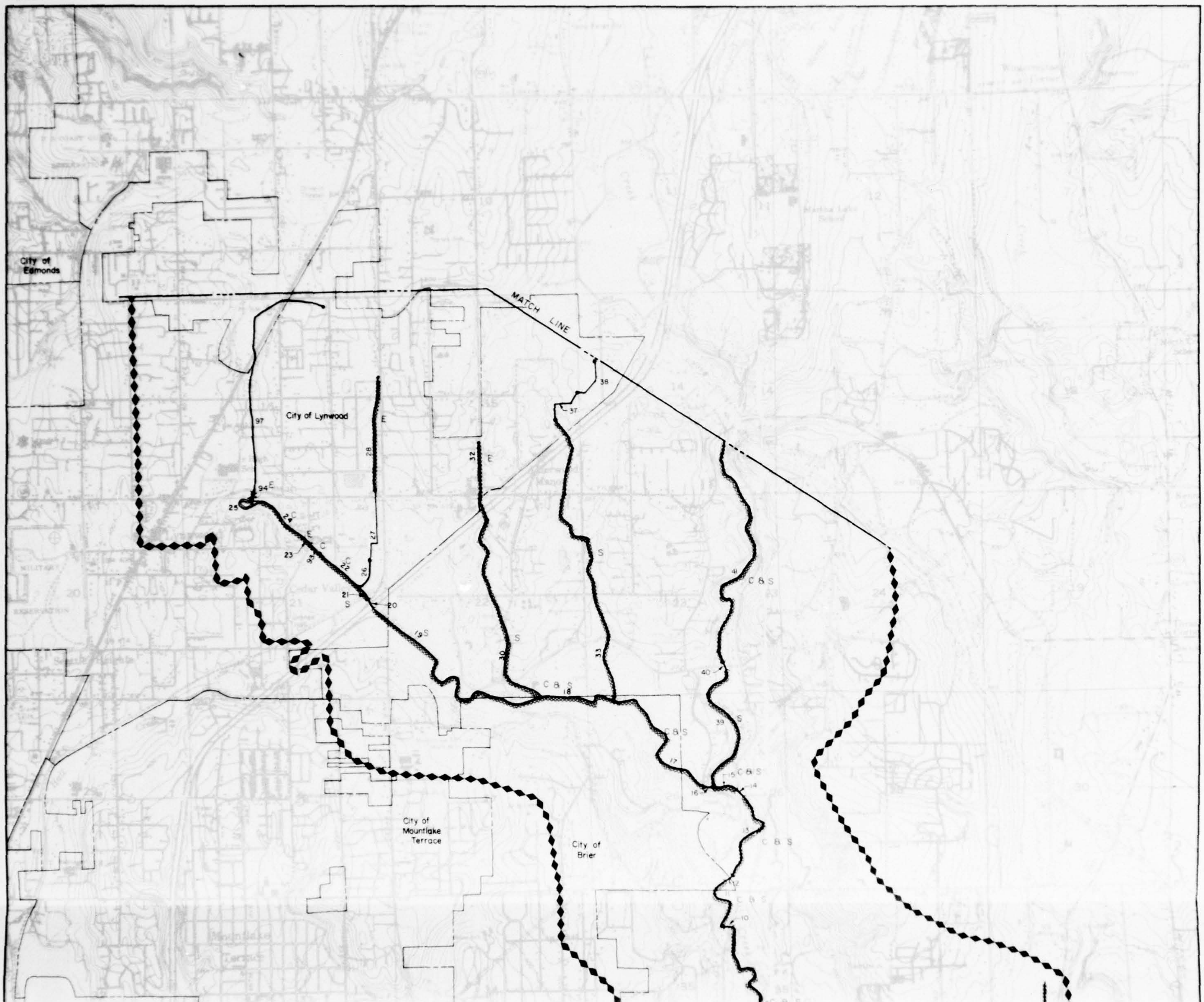
SWAMP CREEK

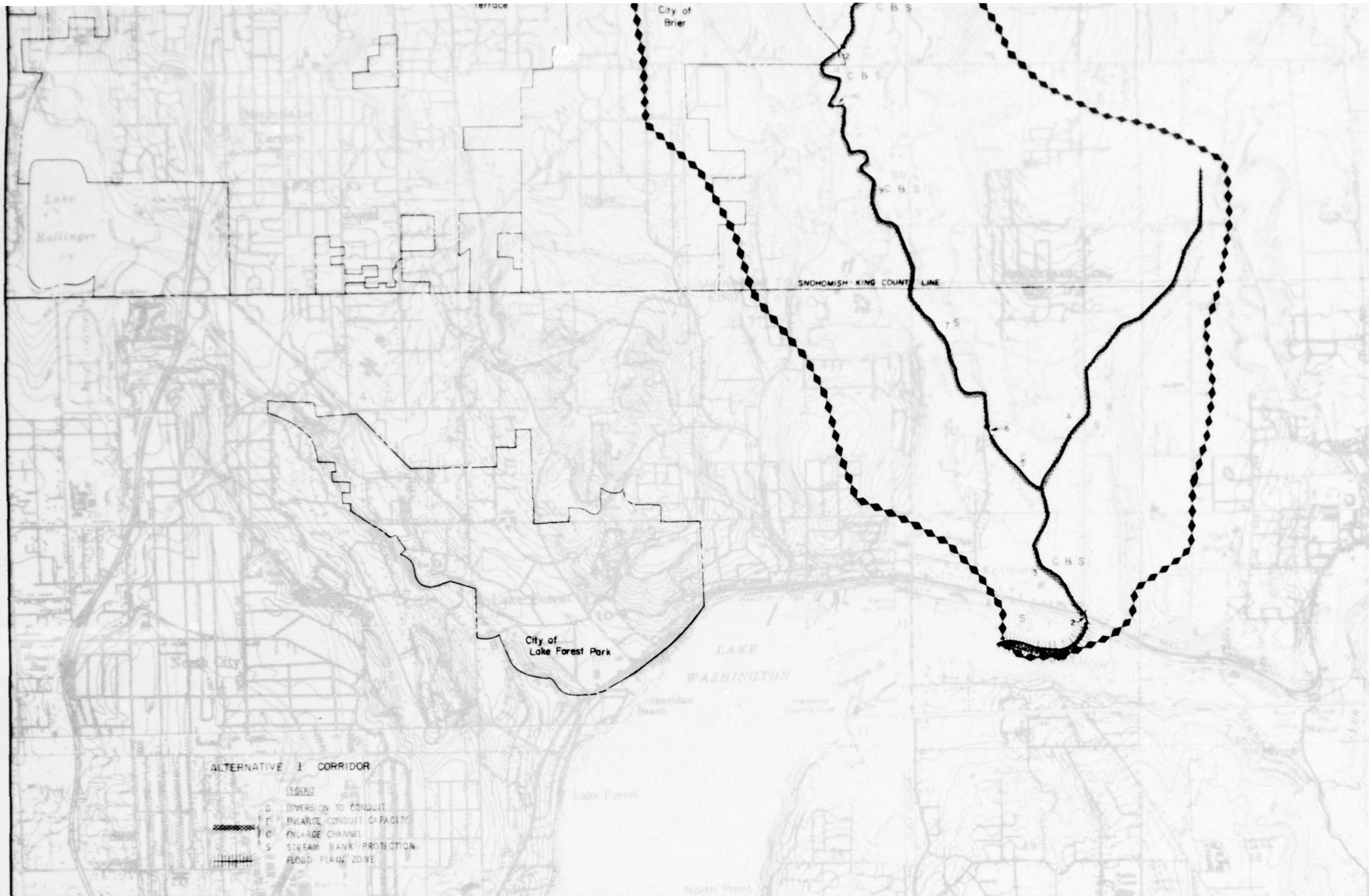
PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

KRAMER, CHIN AND MAYO, INC
WATER RESOURCES ENGINEERS, INC
YODER, TROTTER, ORLOB & ASSOCIATES

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO E-26-1-161 SHEET 1 OF 2


City of Edmonds
City of Lynwood
MATCH LINE
City of Mountlake Terrace
City of Brier
C & S
S
E



LEGEND

SUB-BASIN BOUNDARY
EXISTING CHANNEL
EXISTING CONDUIT
MANHOLE, INLET, OR JUNCTION
CHANNEL OR CONDUIT DESIG.
CITY LIMITS
COUNTY (METRO) BOUNDARY
LEVEE

CULVERT
HOLDING POND OR LAKE

N

1/2 1/4 0 1 MILES

1000 500 0 4000 FEET

NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

SWAMP CREEK

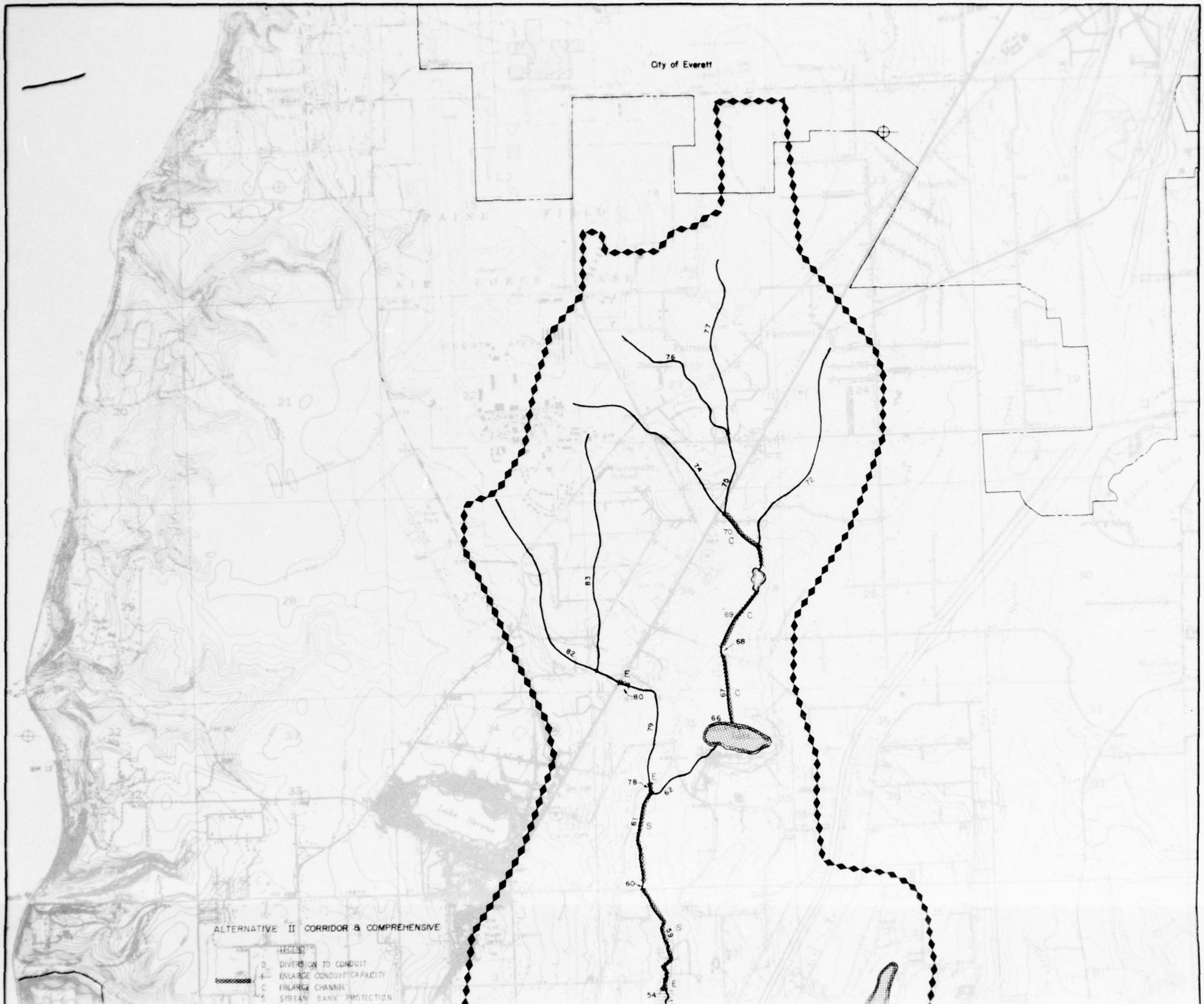
PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

KRAMER, CHIN AND MAYO, INC
WATER RESOURCES ENGINEERS, INC
YODER, TROTTER, ORLOB & ASSOCIATES

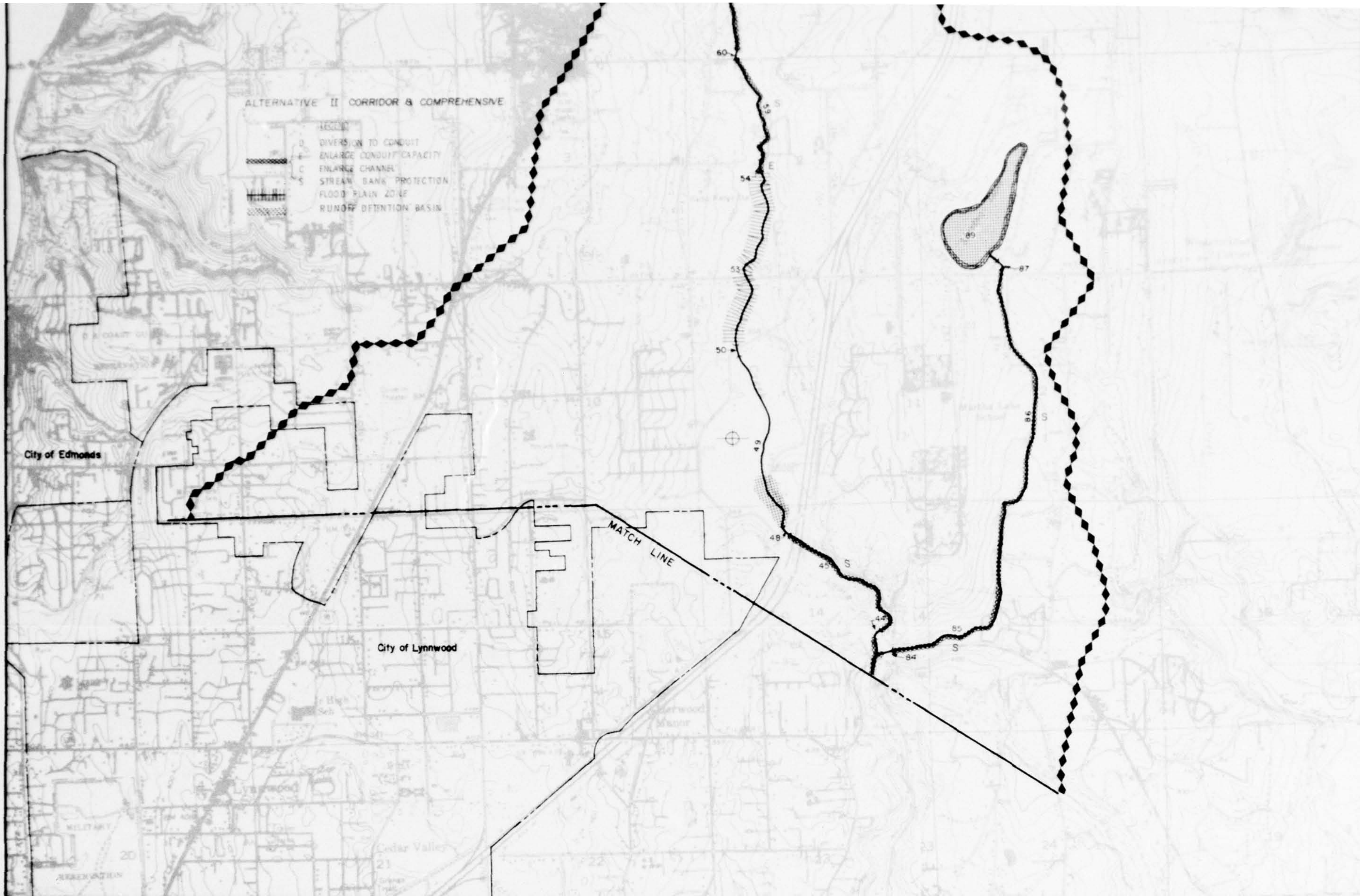
U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO. E-26-1-161 SHEET 2c OF 2

2



City of Everett
PAINE FIELD
AIR FORCE LEASE
Lake Serene
ALTERNATIVE II CORRIDOR & COMPREHENSIVE
LEGEND
D DIVERSION TO CONDUIT
E ENLARGE CONDUIT CAPACITY
C ENLARGE CHANNEL
S STREAM BANK PROTECTION



LEGEND

- SUB-BASIN BOUNDARY
- EXISTING CHANNEL
- EXISTING CONDUIT
- MANHOLE, INLET, OR JUNCTION
- CHANNEL OR CONDUIT DESIG. — 5
- CITY LIMITS
- COUNTY (METRO) BOUNDARY
- LEVEE
- CULVERT
- HOLDING POND OR LAKE

N

1/2 1/4 0 1 MILES

1000 500 0 4000 FEET

NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

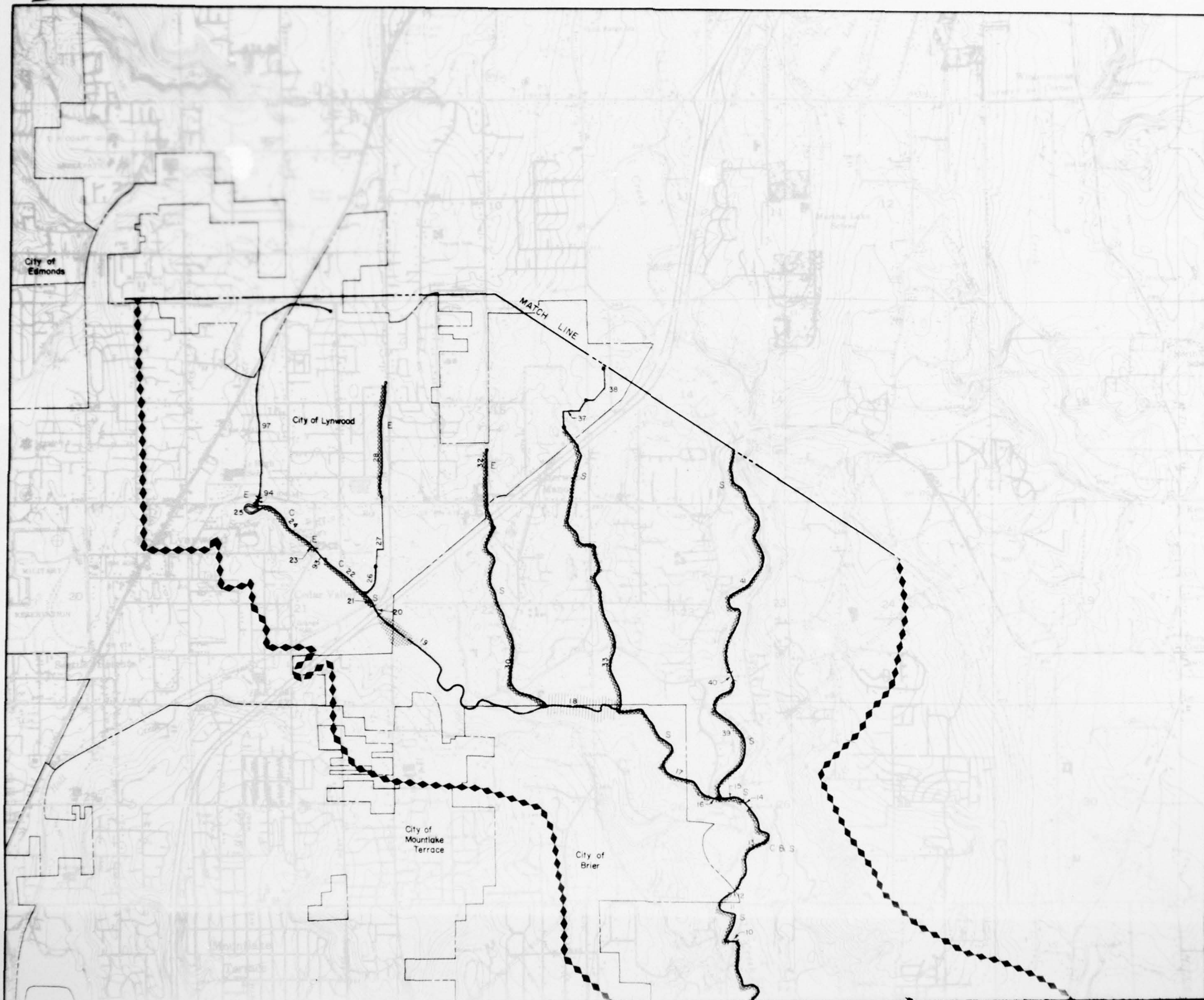
SWAMP CREEK

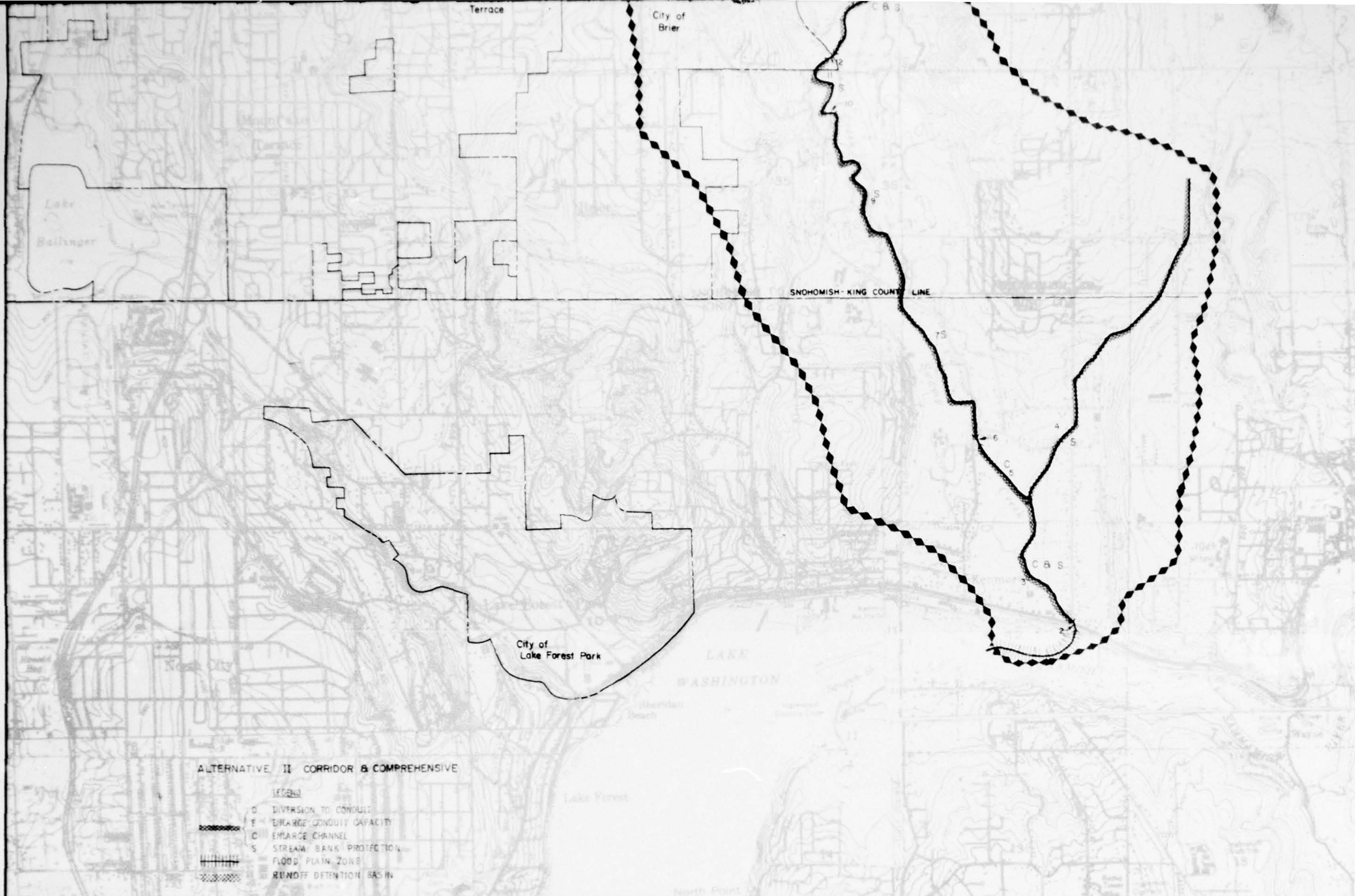
PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

KRAMER, CHIN AND MAYO, INC
WATER RESOURCES ENGINEERS, INC
YODER, TROTTER, ORLOB & ASSOCIATES

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO E-26-1-161 SHEET 1a OF 2


City of Edmonds
City of Lynwood
MATCH LINE
City of Mountlake Terrace
City of Brier
C & S



LEGEND

- SUB-BASIN BOUNDARY
- EXISTING CHANNEL
- EXISTING CONDUIT
- MANHOLE, INLET, OR JUNCTION
- CHANNEL OR CONDUIT DESIG
- CITY LIMITS
- COUNTY (METRO) BOUNDARY
- LEVEE
- CULVERT
- HOLDING POND OR LAKE

N

1/2 1/4 0 1
MILES
1000 500 0 4000
FEET

NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

SWAMP CREEK

PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

KRAMER, CHIN AND MAYO, INC
WATER RESOURCES ENGINEERS, INC
YODER, TROTTER, ORLOB & ASSOCIATES

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO E-26-1-161 SHEET 2d OF 2

2

REGIONAL SUB-BASIN C-9

SAMMAMISH RIVER

GENERAL DESCRIPTION

The Sammamish River Sub-Basin is located directly south of the King County-Snohomish County line and extends from Lake Washington easterly approximately four miles to Woodinville, then southerly eight miles to Lake Sammamish. Only the City of Bothell is located directly within the sub-basin, although the sub-basin itself is bordered in part by Kirkland, Redmond, Woodinville,and Kenmore. Bothell and each of the bordering cities, other than Kirkland, is adjacent to a major tributary (North Creek, Evans Creek, Bear Creek and Swamp Creek, respectively). The Sammamish River flows from its origin in Lake Sammamish to Lake Washington.

The geography of the sub-basin varies considerably. The entire river valley is a broad-plained, gently-sloping alluvial fan. Adjacent to this plain are plateaus and medium hills. The sub-basin boundary is delineated by natural features such as ridge lines and mountain saddles. Where the boundary passes through an urbanized area, such as Redmond and Bothell, the boundary of the sub-basin is governed by man-made features such as street grading and levees.

There is only one principal stream within the sub-basin, that being the Sammamish River. This river, approximately 13 miles long, extends the entire length of the sub-basin, and drops approximately 15 ft. from Lake Sammamish to Lake Washington through a series of natural and man-made levied sections. The stream is considered geologically old, for the natural streambed is sinuous throughout and oxbowed in several places. Portions of the stream, particularly that portion north of Redmond, is aligned in a straight reach by levees that were built by U. S. Army Corps of Engineers and are maintained by King County.

Present land development in the Sammamish River sub-basin is predominately agricultural along the flood plain or undeveloped (wooded) along the adjoining plateaus and hillside areas. Single-family residential areas are interspersed throughout the sub-basin. Development is more dense near the confluence of major tributaries. There also is a low percentage of land use devoted to institutional uses (governmental and educational), and commercial and industrial uses, particularly near the mouth of the River.

Future development trends projected by the Comprehensive and Corridor Land Use Plans for the year 2000 are similar. Almost all existing undeveloped land (40%) is projected to be developed either as open land, such as parks, or as single-family residential. All other land-use types remain about the same as existing levels of development.

PERCENT OF SUB-BASIN AREA IN SPECIFIED LAND USE

Land Use	Existing (1970-72)	P.S.G.C Land Use Projection Comprehensive	P.S.G.C Land Use Projection Corridor
Single Family	10	30	30
Multiple Family		5	5
Commercial/ Services	5	5	5
Govt. and Educ.	5	5	5
Industrial	5	5	5
Parks/Dedicated Open Space	5	20	20
Agriculture	30	20	20
Airports, Railyards, Freeways, and Highways		5	5
Unused Land	40	5	5
Water			
Total	100	100	100
Total Impervious Area	15	30	30

Jurisdiction within the sub-basin is exercised by King County, and in part, by the cities of Kirkland, Redmond, and Bothell.

NATURE OF EXISTING DRAINAGE SYSTEM

The nature of the drainage system is varied. In addition to several major point sources of inflow, the flow in the Sammamish River is affected by both Lake Washington at its mouth and Lake Sammamish at its origin where a static wier is located. The flow within the river is somewhat varied due to both the man-made and "natural" sections. There are no lakes within the sub-basin, nor are there any upland wetlands. The river is fairly well contained within the natural and man-made levees. During high flows in the river, water flows from the main channel into agricultural canals and floods some surrounding lands.

Man-made facilities within the sub-basin consist of major works, such as the levees along the Sammamish River, and ditches for draining adjacent land.

The Sammamish River is important for several reasons. One obvious reason is agricultural benefit. The river-basin, near the major metropolitan area of Seattle, is presently a highly productive agricultural area. Also, it has situated around it natural recreational areas for hiking, boating and fishing. The river provides an important passageway for coho and chinook salmon.

DRAINAGE PROBLEMS

The major problems in the Sammamish River Sub-Basin, as reported by local citizens and as simulated with computer models, is flooding of lands directly adjacent to the Sammamish River and along some tributaries. Point source inflows from Lake Sammamish, Evans Creek, Bear Creek, North Creek, and Swamp Creek were not considered in this analysis. Therefore, the term tributaries, as defined herein, refers to agricultural drainage streams, man-made drains from the cities of Redmond and Bothell, and similar water courses. The flooding problems tend to be concentrated near population centers, such as Bothell, Woodinville, and Redmond. The severity of the problems is presently moderate, although in future years these problems will become more acute.

The recent Sammamish River channel improvements by the Corps of Engineers, with local sponsorship by King County, were constructed to accommodate 1,500 cfs at the Lake Sammamish outlet and discharge 1,900 cfs into Lake Washington. However, the projected 10-year peak flows for the three main tributary streams, (North, Bear and Evans Creeks) under P.S.G.C.'s year 2000 land use plan total more than 2,500 cfs. Therefore, the existing Sammamish River Channel cannot accommodate the peak rates of runoff under the projected year 2000 land use.

Problems consist of ponding near Snyders Corner, erosion and ditch flooding in Redmond, stream flooding and ponding near Earlmont and Willows, ditch flooding, ponding, erosion and slides around Bothell, and debris deposits, stream and ditch flooding, and erosion near Kenmore.

It is significant that the year 2000 Comprehensive Land Use differs from the year 2000 Corridor Land Use in the Sammamish River Sub-Basin. As seen in the preceding table of land uses, the total existing impervious area is 15% and is expected to increase under both land-use projections to approximately 30%. The major difference in the two land-use plans is in the geographic location of the various land uses and the runoff that would result.

The conclusion reached by directly comparing the results of the computer simulations is significant; Comprehensive Plan flows exceed (by about 20%) that of the Corridor Plan in almost all upstream reaches. In the downstream reaches, flows are almost identical. Because the Comprehensive Plan shows larger peak flows than the Corridor Plan, the Comprehensive Plan has been used for the development of the preliminary alternative plans described below.

BASIC ISSUES AND STATUS OF DRAINAGE PLANNING

The Corps of Engineers has been actively involved in past planning for this sub-basin, but does not have any planning underway at this time. The City of Redmond and Bothell both have, in part, storm drainage master plans.

Future land-use projections indicated in both the Year 2000 Comprehensive Plan and Corridor Plan have principally well developed non-conflicting land-use outlines that coordinate well with the natural features within the sub-basin.

Staff members from King County Public Works Department, Hydraulics Division and the City of Redmond Engineering and Planning Departments have reviewed the initial alternative plans for drainage developed by this RIBCO Study for the Sammamish River Sub-Basin.

ALTERNATIVE PLANS FOR PROPOSED DRAINAGE CONTROL

The existing drainage system of the Sammamish River Sub-Basin as described by local agencies, was evaluated by computer simulation that applied the region's 10-year storm to P.S.G.C. year 2000 land use. Drainage problems thus identified were analyzed and possible solutions provided for development of alternative plans for drainage control as described below.

ALTERNATIVE PLAN I

General Concept

This concept deals primarily with placement of parallel pipelines and flood-plain zoning to solve the flooding and erosion problem.

Major Features

Computer simulation indicates flooding will occur principally in the City of Bothell and along several tributaries south of Woodinville.

Where flooding is expected to occur such as in Woodinville or Bothell, a parallel pipeline with sufficient capacity to convey the flow in excess of the capacity of present facilities was used to alleviate flooding.

In contrast to this parallel pipeline, if flooding is expected to occur in an area that is predominantly agricultural, such as between Redmond and Woodinville, the concept of flood-plain zoning was used. Flood-plain zoning is recommended for all areas directly adjacent to the Sammamish River.

Cost

The cost for this alternative is estimated to be $900,000.

ALTERNATIVE PLAN II

General Concept

This concept is identical to Alternative Plan I, except land use controls are added.

Major Features

The most significant feature of this alternative is that of land-use control. Essentially, development is controlled in the sub-basin so that runoff is limited to approximately the same level that would occur under present conditions.

Presently, King County has a storm drainage policy for land development that states, "... drainage plans shall provide storm water retention facilities so that peak discharge from the site will not be increased by more than 25% due to the proposed development."

Both parallel pipelines and flood-plain zoning will be required in the Sammamish River Sub-Basin even if the land use controls are imposed on all new development.

Because land-use control creates less runoff per unit area, the size of parallel pipelines and area of flood plains will be less than that required for Alternative Plan I.

Cost

The cost for this alternative is estimated to be $700,000.

PEAK FLOW COMPARISONS

The following table indicates 10-year peak flows under existing facilities and under alternative drainage management solutions for the year 2000. The peak flows are given for locations noted.

COMPARISON OF 10-YEAR PEAK FLOWS
(Cubic Feet Per Second)

Location	Facilities	Alternative Plan I	Alternative Plan II
1/2 Mile Downstream from Redmond	360	430	160
1st Tributary on West Side, Downstream from Redmond	480	480	240
Willows	860	880	470
Hollywood	840	870	520
Bothell Bridge	580	640	420
SR527	90	280	190
Wayne	530	550	370
Mouth	450	530	370

ENVIRONMENTAL ASSESSMENT OF ALTERNATIVE PLANS

Field inspections were made to judge the applicability of the suggested alternative plans for this sub-basin. This procedure was followed throughout the RIBCO Study in developing alternative plans for the various regional sub-basins. The inspections were based on the alternative evaluation procedure which identified 34 unique criteria grouped in general categories as follows: 1) Effectiveness, 2) Human Values, 3) Environmental Factors, 4) Implementation, and 5) Resource Requirements. The various structural solutions were checked against the appropriate criteria and the various non-structural solutions were reviewed for their relationship to existing and probable future developments. The criteria rating total for Alternative Plan I, which employs diversion, some enlarged conduit and flood-plain zoning, is a plus 39 on a scale ranging from a positive total of 108 to a negative total of 108. The total evaluation rating for Alternative Plan II, which employs some enlarged conduit, diversion, flood-plain zoning, and runoff control for future development was a plus 64.

Both alternative plans are judged to be highly effective for controlling runoff under future land-use conditions. Both alternatives also received positive ratings for promotion of human values. Alternative Plan II received a nearly perfect score for environmental factors because of its combination of runoff control and flood-plain zoning. It was felt that water quality, low-flow conditions, the groundwater table and the

natural drainage system all will be enhanced by use of this system. Alternative Plan I also received a positive rating on environmental factors but does not provide the same protection of water quality or low-flow conditions nor does it enhance groundwater recharge. Both alternative plans are judged to be equally difficult to implement as they involve cooperative action of two jurisdictions and to be successful they must be initiated in the fairly immediate future. Resource requirements are not extensive for either alternative reflecting in positive ratings in this category.

A critical element common to both alternatives is the proposal to use flood-plain zoning along the various feeder tributaries. This treatment, if it is to be part of the chosen alternative, should be implemented as an early organized effort of the involved agencies. Any development which occurs within the designated flood-plain areas, will force the use of more complex drainage control than either alternative contemplates. Alternative Plan II, in addition, relies upon control of runoff from new development to no more than 25% of existing volume. This provision, again, requires immediate attention by the involved local agencies. These issues should be brought to the attention of all affected citizens and their local governments. It also should be understood that both alternatives, because they suggest flood-plain zoning, would effectively remove that portion of the sub-basin that is within the designated flood-plain zone from any future intensive land uses typical of urbanized areas.

CONCLUSIONS

While both alternatives received positive ratings, Alternative Plan II is superior to Alternative Plan I because it does not require extensive structural work within the sub-basin and it assures water quality and low-flow conditions in the various tributaries.

King County and the City of Bothell should establish an effective agreement for a master drainage plan that incorporates the provisions of Alternative Plan II. Both agencies should then move to implement and enforce required flood-plain zoning within their own jurisdictions and make provisions to assure that runoff controls are part of future development. Because of the extensive sub-basin land area within King County jurisdiction, the County should have responsibility for control of drainage and flood damage within the Sammamish River Sub-Basin; the City of Bothell and King County should enforce zoning, including flood-plain zoning, within their respective boundaries and concurrent jurisdiction in the outer fringe areas of the City of Bothell.

RUNOFF QUALITY SUMMARY
SAMMAMISH RIVER

BASED UPON A 10-YEAR STORM PRECEDED BY 15 DAYS WITH LITTLE OR NO RAINFALL#

LOCATION	ALTERNATIVE PLAN	PEAK FLOW (cfs)	CONCENTRATION AT PEAK FLOW*				
			BOD	TOTAL COLIFORM	NH_3	$NO_2 + NO_3$	PO_4
State Route 527	I	280	19	1.0×10^6	1.0	1.6	.2
	II	190	23	1.2×10^6	1.2	1.9	.2
First west tributary downstream from Redmond	I	480	8	1.2×10^5	.2	.7	.1
	II	240	11	1.6×10^5	.3	.9	.1

Less than a total of 0.5 inches of rainfall in any one day.
* Concentrations in mg/liter except total coliform which is in MPN/100 ml.

EVALUATION MATRIX

SAMMAMISH RIVER

ALTER-NATIVES	EFFECTIVENESS SUB TOTAL	Use of existing facilities	System reliability	System maintainability	System flexibility	Flood damage reduction	Consequences of overcharge	Erosion and sedimentation control	Cost/benefits ranking	HUMAN VALUES SUB TOTAL	Urban quality (aesthetics)	Effect on land use	Displacement of people	Educational value	Community cohesion	Multiple use potential	Public health and safety	ENVIRONMENTAL FACTORS SUB TOTAL	High flow conditions	Alteration of natural system	Effects on groundwater	Low flow conditions	Water quality	Construction disruption	Effects on wildlife	Effects on aquatic life	Effects on vegetation	IMPLEMENTATION SUB TOTAL	Legislative requirements	Jurisdictional	Land acquisition	Public acceptance	Financing	Effects of no action	RESOURCE REQUIREMENTS SUB TOTAL	Energy	Materials	Land	Capital	RATING TOTAL
CRITERIA WEIGHT		1	4	3	2	4	4	4	2		4	2	2	1	3	3	4		4	4	4	4	4	2	4	4	4		4	4	2	4	4	3		3	3	2	2	
I	+16									+7								+14										-2							+4					+39
II	+24									+8								+30										-2							+4					+64

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative I Sub-Basin Sammamish River

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
12	Pipe	18"	1,000'			Parallel Pipe	24"	$42,000
14	Pipe	54"	900'			Parallel Pipe	24"	$38,000
15	Pipe	36"	2,600'			Parallel Pipe	24"	$109,000
19	Pipe	24"	3,000'			Parallel Pipe	24" 1,500'	$63,000
22	Pipe	18"	3,300'			Parallel Pipe	24"	$139,000
28	Channel	18"	10,000'	1.5:1	2'	Diversion Pipe	48" 5,000'	$465,000
28	None					Inlet/ Outlet	To Element 28	$8,000

The Estimated Capital Cost for each element includes Contractor profit, engineering, legal and contingencies. In addition, land purchase and severance costs are included where land is required. All costs are based upon June 1973 prices.

Total Estimated Capital Cost: $864,000

Round To: $900,000

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

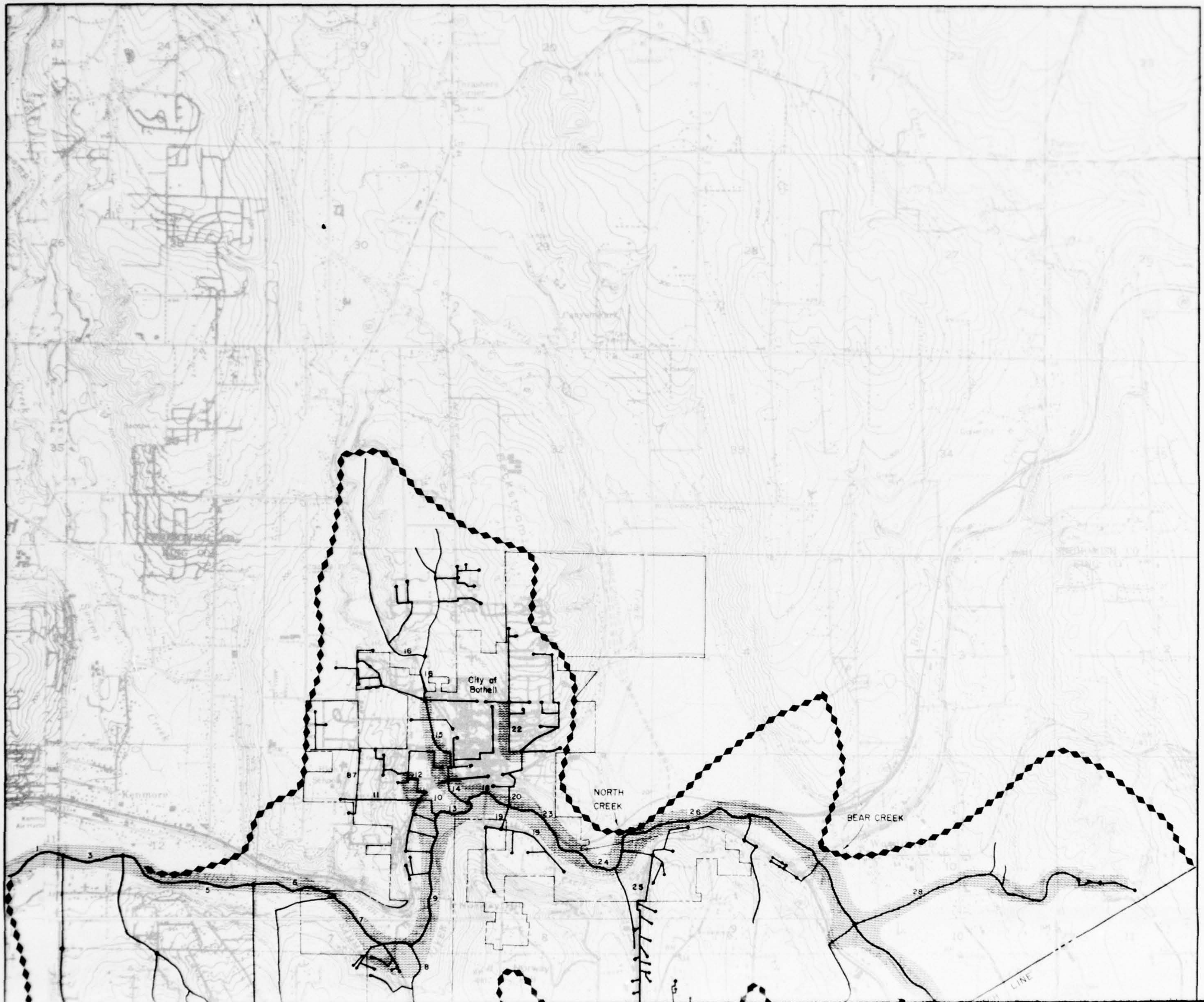
Alternative II Sub-Basin Sammamish River

ELEMENT NUMBER	EXISTING FACILITIES: TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	PROPOSED FACILITIES: TYPE		ESTIMATED CAPITAL COST
12	Pipe	18"	1,000'			Parallel Pipe	24"	$42,000
15	Pipe	36"	2,600'			Parallel Pipe	24"	$109,000
19	Pipe	24"	3,000'			Parallel Pipe	24" 1,500'	$63,000
22	Pipe	18"	3,300'			Parallel Pipe	24"	$139,000
28	Channel	18"	10,000'	1.5:1	2'	Diversion Pipe	36" 5,000'	$330,000
28	None					Inlet/ Outlet	To Element 28	$6,000

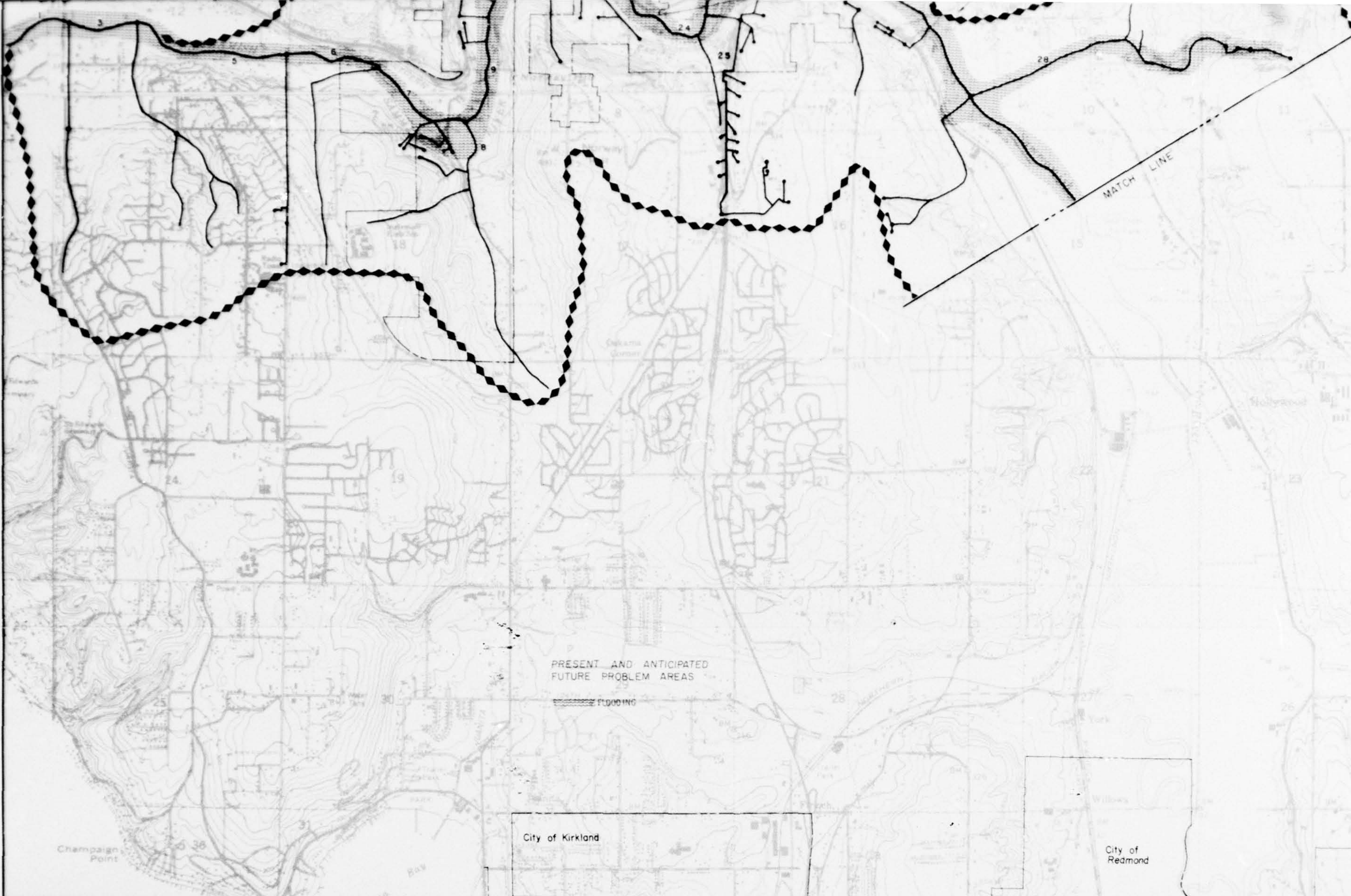
The Estimated Capital Cost for each element includes Contractor profit, engineering, legal and contingencies. In addition, land purchase and severance costs are included where land is required. All costs are based upon June 1973 prices.

Total Estimated Capital Cost: $689,000

Round To: $700,000

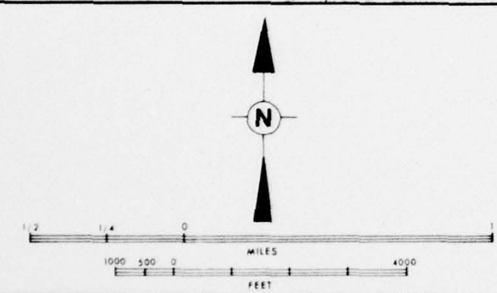


City of Bothell
NORTH CREEK
BEAR CREEK
Kenmore
LINE



LEGEND

SUB-BASIN BOUNDARY	
EXISTING CHANNEL	
EXISTING CONDUIT	
MANHOLE, INLET, OR JUNCTION	
CHANNEL OR CONDUIT DESIG.	5
CITY LIMITS	
COUNTY (METRO) BOUNDARY	
LEVEE	
CULVERT	
HOLDING POND OR LAKE	



NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

SAMMAMISH RIVER

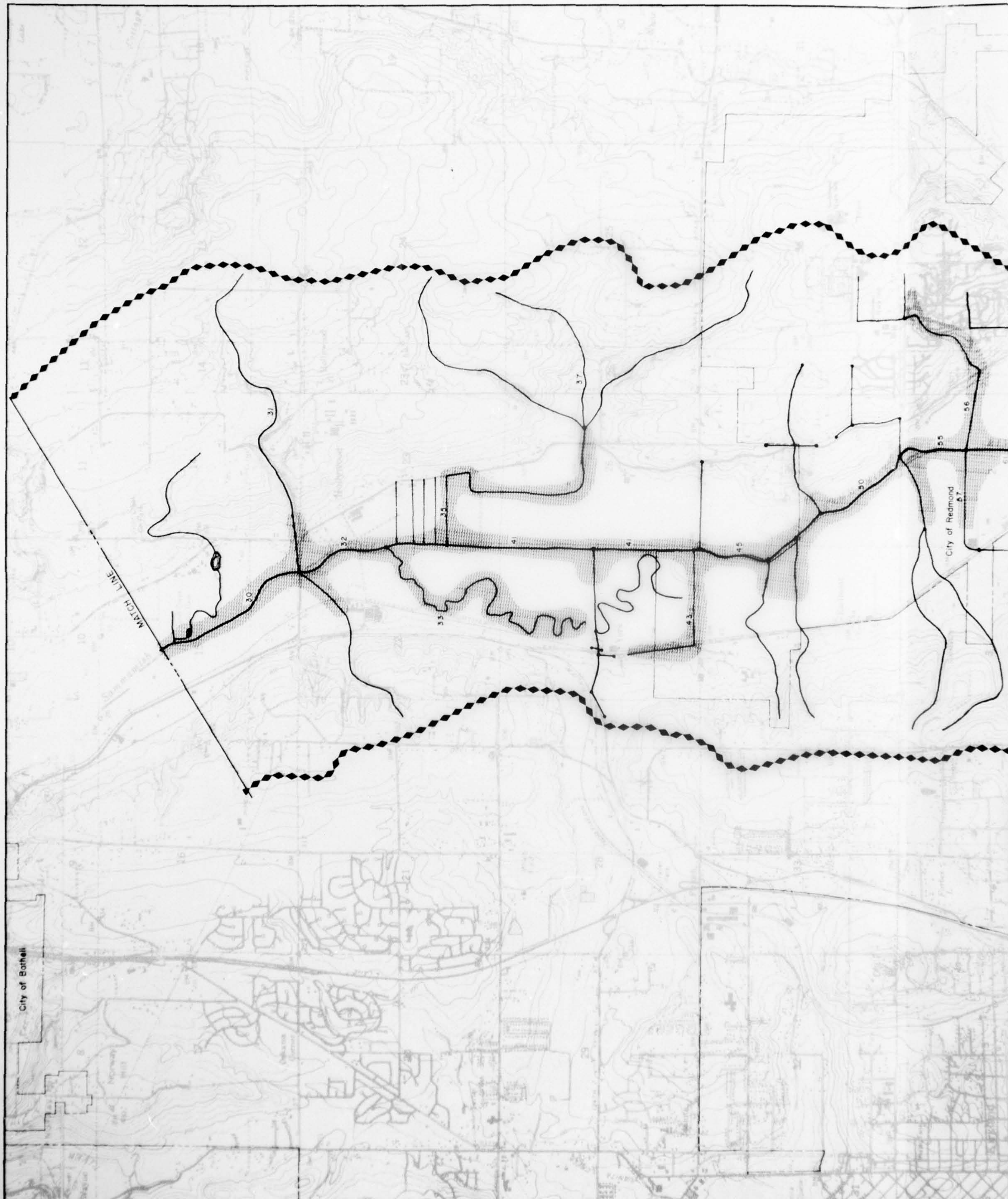
PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

KRAMER, CHIN AND MAYO, INC
WATER RESOURCES ENGINEERS, INC
YODER, TROTTER, ORLOB & ASSOCIATES

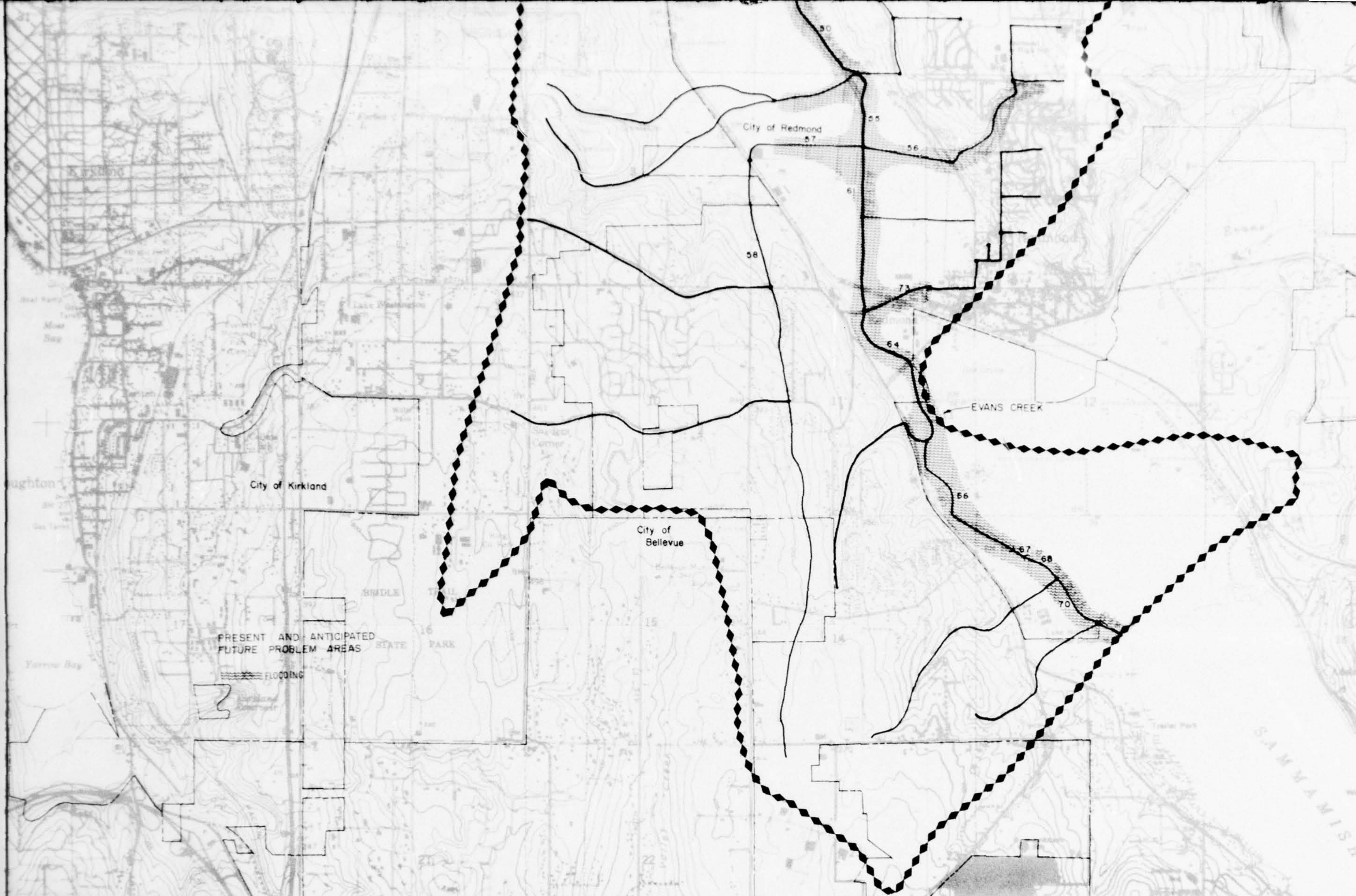
U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO E-26-1-161 SHEET 1 OF 2

2



MATCH LINE
City of Bothell
City of Redmond
30
31
32
33
35
37
41
43
45
50
55
56
57



LEGEND

- SUB-BASIN BOUNDARY
- EXISTING CHANNEL
- EXISTING CONDUIT
- MANHOLE, INLET, OR JUNCTION
- CHANNEL OR CONDUIT DESIG. 5
- CITY LIMITS
- COUNTY (METRO) BOUNDARY
- LEVEE
- CULVERT
- HOLDING POND OR LAKE

N

1/2 1/4 0 1 MILES

1000 500 0 4000 FEET

NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

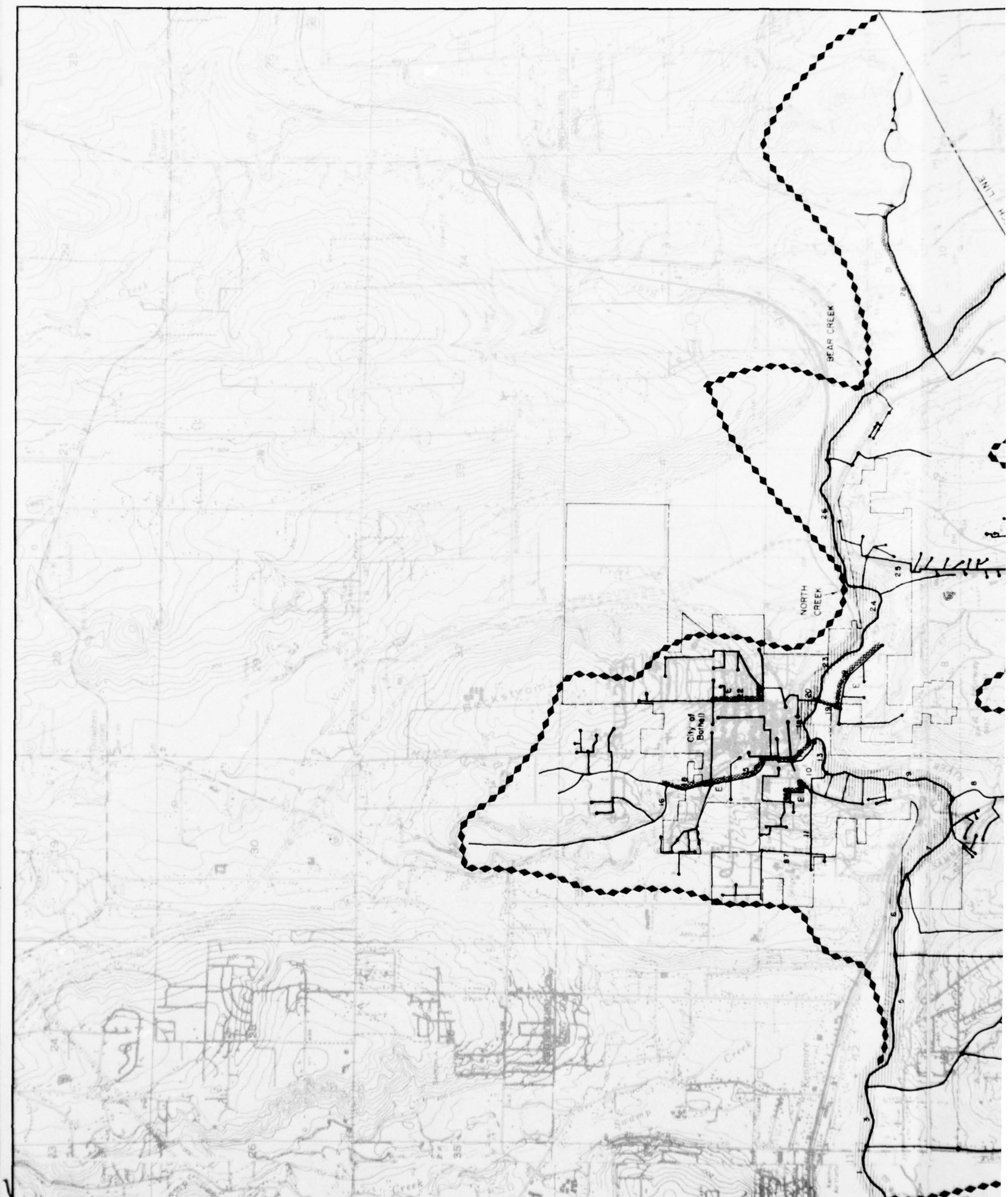
SAMMAMISH RIVER

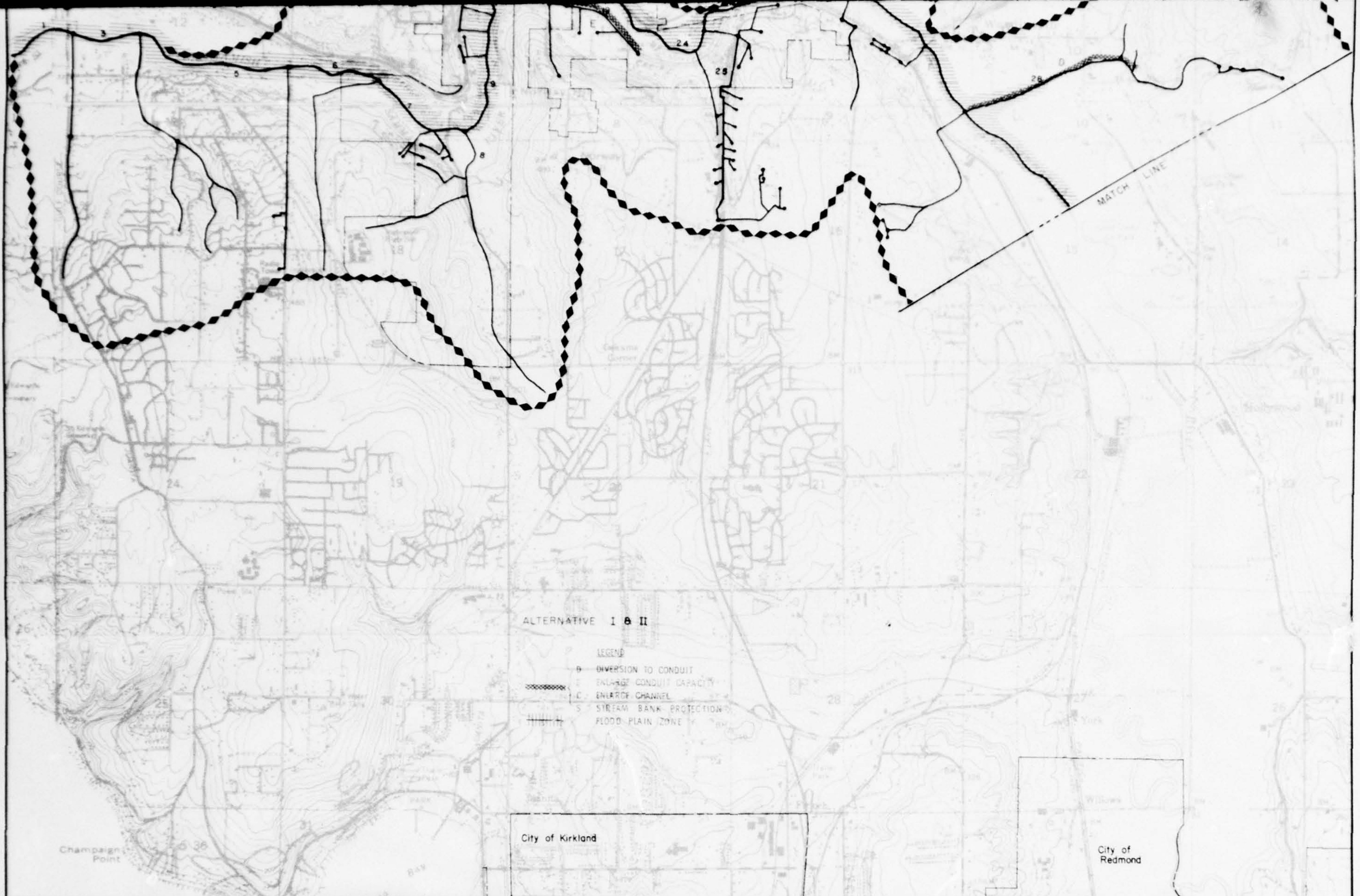
PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

KRAMER, CHIN AND MAYO, INC
WATER RESOURCES ENGINEERS, INC
YODER, TROTTER, ORLOB & ASSOCIATES

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO. E-26-1-161 SHEET 2 OF 2


BEAR CREEK
NORTH CREEK
City of Bothell
Kenmore
Swamp
Creek



LEGEND

SUB-BASIN BOUNDARY
EXISTING CHANNEL
EXISTING CONDUIT
MANHOLE, INLET, OR JUNCTION
CHANNEL OR CONDUIT DESIG. 5
CITY LIMITS
COUNTY (METRO) BOUNDARY
LEVEE

CULVERT
HOLDING POND OR LAKE

N

1/2 1/4 0 1
MILES
1000 500 0 4000
FEET

NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

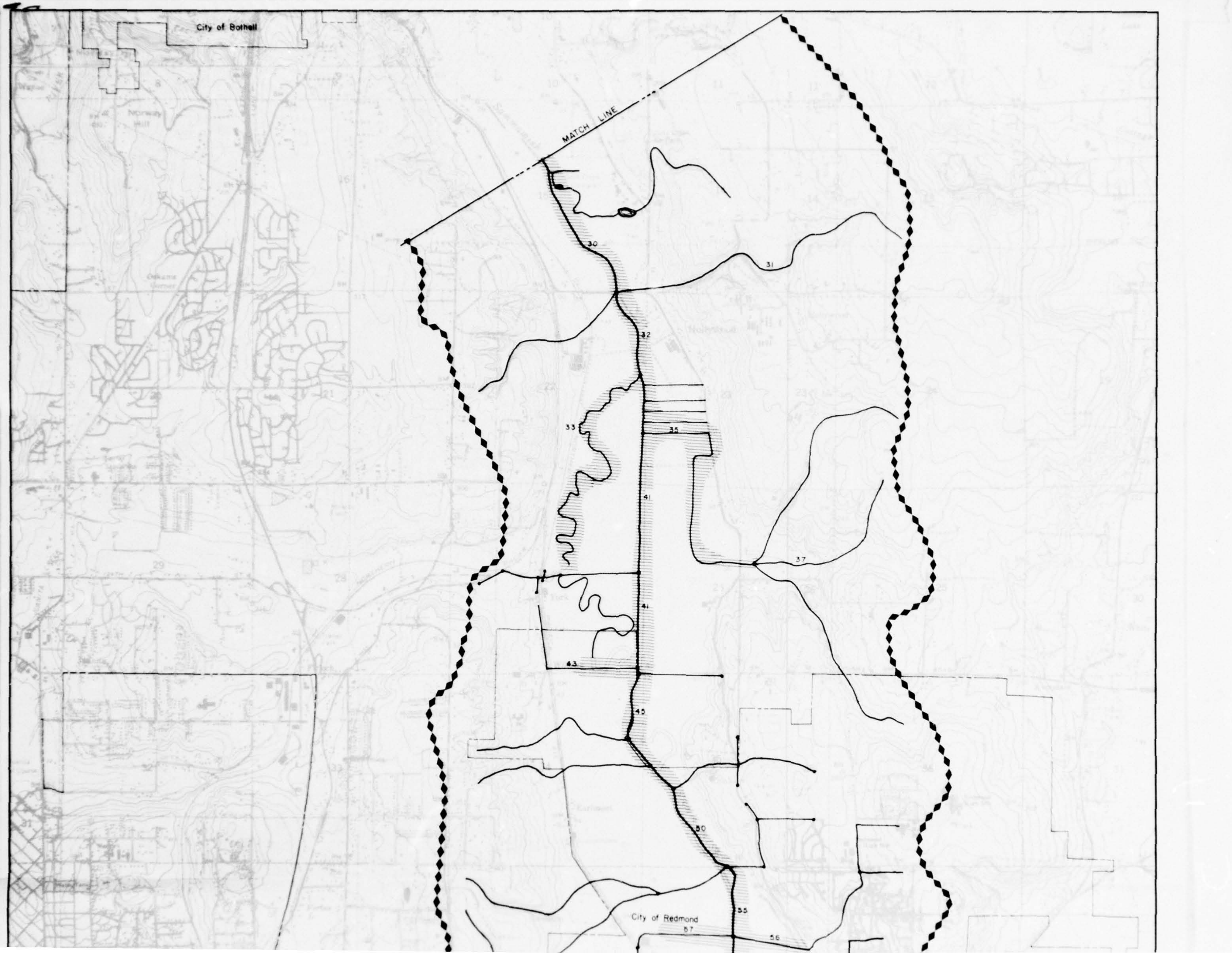
SAMMAMISH RIVER

PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

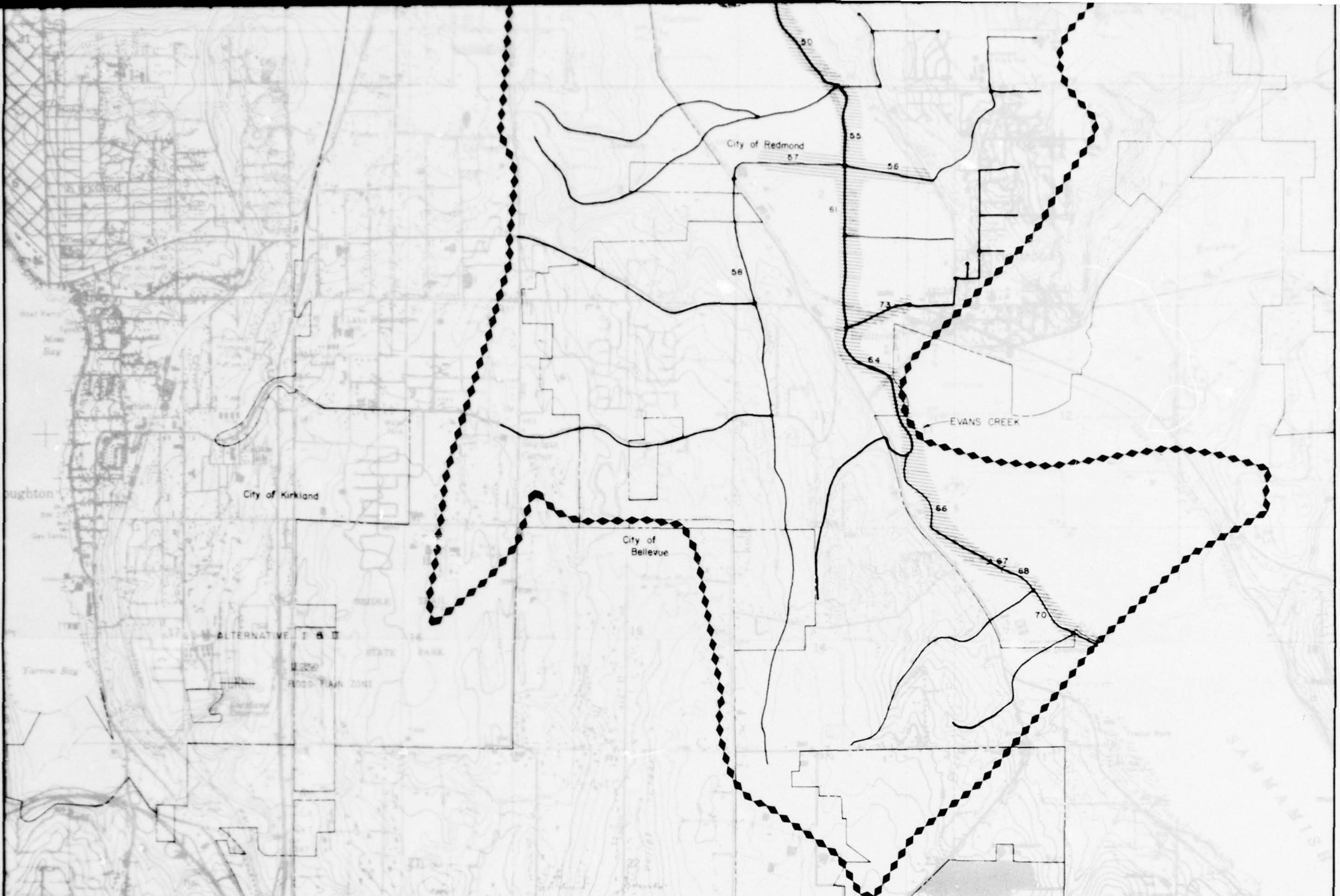
KRAMER, CHIN AND MAYO, INC.
WATER RESOURCES ENGINEERS, INC.
YODER, TROTTER, ORLOB & ASSOCIATES

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO. E-26-1-161 SHEET 1b OF 2



City of Bothell
MATCH LINE
30
31
32
33
35
37
41
41
43
45
50
55
56
57
City of Redmond



LEGEND

SUB-BASIN BOUNDARY
EXISTING CHANNEL
EXISTING CONDUIT
MANHOLE, INLET, OR JUNCTION
CHANNEL OR CONDUIT DESIG. 5
CITY LIMITS
COUNTY (METRO) BOUNDARY
LEVEE

CULVERT
HOLDING POND OR LAKE

N

MILES: 1/2, 1/4, 0, 1

FEET: 1000, 500, 0, 4000

NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

SAMMAMISH RIVER

PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

KRAMER, CHIN AND MAYO, INC
WATER RESOURCES ENGINEERS, INC
YODER, TROTTER, ORLOB & ASSOCIATES

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO E-26-1-161 SHEET 2b OF 2

REGIONAL SUB-BASIN C-10

JUANITA CREEK

GENERAL DESCRIPTION

Juanita Creek Sub-Basin lies north of Kirkland within the drainage divide established by 84th Avenue Northeast, the Sammamish River basin and N.E. 116th Street. The head of Juanita Creek is east of Interstate 405 near the Kingsgate residential area. The stream discharges to Lake Washington at Juanita Beach.

The sub-basin geography is rolling glaciated upland area typical of the Puget Sound region. The sub-basin rises from 15ft. elevation at the rather flat estuary and valley of Juanita Bay to elevations greater than 300 feet near the I-405 Freeway. Several smaller valleys with mild slopes up to the higher ridges and plateaus give the sub-basin a well-defined natural drainage system.

Several smaller streams, some of which are fed by springs, converge with Juanita Creek throughout its entire course. Juanita Creek is currently being gaged near its mouth by the U. S. Geological Survey.

The sub-basin has undergone a steady transition from rural to urban residential land use. Storm-drainage systems, constructed for each new development, discharge directly to Juanita Creek or to its small tributaries. Flow volumes and peak discharge rates are increasing. The land-use pattern is expected to intensify as shown in the following table prepared from PSGC records.

Streams	Category	Drainage Area	Discharge
Juanita Creek	III	7 sq. mi.	Lake Washington

PERCENT OF SUB-BASIN AREA IN SPECIFIED LAND USE

Land Use	Existing (1970-72)	P.S.G.C. Land Use Projection Comprehensive	Corridor
Single Family	64	80	80
Multiple Family		2	2
Commercial/Services	5	5	5
Govt. and Educ.	5	3	3

Land Use	Existing (1970-72)	P.S.G.C. Land Use Projection Comprehensive	Corridor
Industrial		5	5
Parks/Dedicated Open Space		1	1
Agriculture	5		
Airport, Railyards, Freeways, Highways	1	1	1
Unused Land	20	3	3
Water			
Total	100	100	100
Total Impervious Area	30	35	35

There currently is pressure to develop commercial properties around Totem Plaza and major arterials. Medium to high-density residential tracts may be anticipated as the east side of Lake Washington expands as a major commercial-employment center. King County has jurisdiction over approximately 90% of the sub-basin. A small portion of the uplands north of N.E. 145th Street and west of 100th Avenue N.E. is in the City of Bothell, and the area between N.E. 116th and N.E. 132nd Streets between 116th and 124th Avenues N.E. is within the City of Kirkland corporate limits.

Stream gradients within the sub-basin vary from flat to mild. The flat boggy areas, such as along N.E. 124th Street, are poorly drained.

Numerous culverts across roads establish grade control. Many of the road crossings, bridges and culverts, were constructed when the sub-basin was rural and have inadequate capacity for current conditions. Upland areas contained several bogs and small lakes at one time, but these have been gradually filled for project development. Runoff velocities and peak flows will continue to increase as this type of development takes place. The natural stream system is the main collector drain for several suburban projects and the sub-basin as a whole, and all available wetlands serve to reduce peak rates of flow in the natural system.

NATURE OF EXISTING DRAINAGE SYSTEM

The existing drainage system consists of the natural flowing stream and its tributaries, several wetland areas acting as filtration and retention basins, and a partial system of lateral storm drains and culverts and bridges. Lake Whittenmeyer is the only named body of water in the Juanita Creek Sub-Basin. The stream course, wetlands, and ravines still are easily

identified within the sub-basin and they serve as an existing urban amenity in this developing part of the central Puget Sound region. Although the stream is being encroached upon by urban development, it still has significant natural areas that support wildlife commonly found in this area.

BASIC ISSUES AND STATUS OF DRAINAGE PLANNING

King County has developed a preliminary drainage plan for the sub-basin that would utilize a closed-conduit drainage system to relieve natural channels of excess flow. The plan has not been actively pursued for several years and would need to be revised to reflect current development. King County has almost exclusive jurisdiction over development and could effect a plan to preserve the remaining natural channels and upland holding pond sites. With nearly 65% residential development already, there is little time remaining to develop effective controls.

Staff members from the King County Department of Public Works, Hydraulics Division, were available for consultation during preparation of the two alternatives for the Juanita Creek Sub-Basin.

DRAINAGE PROBLEMS

This sub-basin is typical of many urbanizing areas where runoff is carried by natural watercourses. Increasing runoff rates have caused flooding and erosion problems through much of the lower areas, especially along Juanita Creek which conveys all runoff leaving the sub-basin. Many culverts are no longer adequate to carry peak flows and stream channels are badly eroded in several places. Debris accumulations and sediment deposition in the streams cause maintenance problems and increase flood hazards. Also, sedimentation can adversely affect the fisheries resource of Juanita Creek.

As the sub-basin develops, these problems will increase unless effective drainage planning is undertaken. Though the sub-basin is substantially developed, there are still relatively large, undisturbed wetland areas that greatly reduce peak runoff rates. Much of the remaining wetlands are along the southern tributary of Juanita Creek that drains the Totem Lake Shopping Center. If this area and other similar areas continue to develop as they have in the past, runoff rates will increase inordinately.

The results of hydrologic analysis indicate no significant difference between the comprehensive and corridor land use plans. Therefore, the drainage alternatives presented herein are applicable to both plans.

As seen from the previous table on projected land uses under the year 2000 Comprehensive and Corridor Plans, only a 5% increase in imprevious area above the existing 30% total impervious coverage, is foreseen for the Juanita Creek Sub-Basin. A primary purpose in developing alternatives for this sub-basin will be to solve problems that have been created by the existing urbanization.

ALTERNATIVE PLANS FOR PROPOSED DRAINAGE CONTROL

The existing drainage system of the Juanita Creek Sub-Basin, as described by local agencies was evaluated by computer simulation applied to the regions 10-year storm to P.S.G.C. year 2000 land use. Drainage problems thus identified were analyzed and possible solutions were provided for development of alternative plans for drainage control as described below.

ALTERNATIVE PLAN I

General Concept

This alternative relies upon conventional methods of storm drainage to reduce flooding and erosion problems. Development would be allowed to continue as it has in the past and downstream facilities would be enlarged to carry the increased runoff rates. The creek itself would be modified considerably.

Major Features

The major element of the drainage system would continue to be Juanita Creek. All surface water would continue to drain to the creek. Enlargement of individual storm drains and culverts throughout the sub-basin would be required. As a result, flows in the natural open channels would increase sufficiently to necessitate major channel construction. Several sections of Juanita Creek would need to be enlarged and most of the open channels would require bank protection to minimize erosion. Even though the costs of such a plan are relatively high, flooding would not be eliminated along the open channels. It is not possible to design an economical system to carry maximum event flows. The channel and conduit capacities sized in the alternative would be exceeded on some occasions. Consequently, it is important that another element be included in this alternative, floodplain zoning. Along the floodplain of lower Juanita Creek, and in all areas of known flooding, incompatible structures and fill would not be allowed. There are few existing homes within the floodplain and those that are could be afforded some considerations during the channel-enlargement and bank-protection construction.

Costs

The cost of this alternative is estimated to be $1,900,000.

ALTERNATIVE PLAN II

General Concept

This alternative makes use of recent innovations in drainage planning, including runoff control. The emphasis of the alternative is upon preserva-

tion of the natural watercourse and adjacent wetlands with as little disturbance as possible.

Major Features

The most important aspect of this alternative is runoff control. King County has recently developed guidelines for areas such as Juanita Creek which require major developments to control peak runoff leaving their property to existing levels or values not greater than 25% above existing levels. Using the King County runoff limitation as a basis, runoff rates were developed that are slightly above present rates but not as high as the future rates as indicated in Alternative Plan I. This on-site runoff control alone is not sufficient to solve the sub-basin's future drainage problems because some problems exist now, and the installation of improved storm-drainage systems will further increase downstream flow, even if runoff rates from major developments are controlled. Therefore, this alternative includes the installation of several holding ponds in the sub-basin and the enlargement of several culverts and channel sections that are inadequate, even with upstream control.

Not all the holding ponds planned would be perennial bodies of water. Only Lake Whittenmeyer, the pond at N.E. 133rd Place and 105th Avenue N. E., and the stream identified as Element 36 would have significant water impounded year-round. The remaining ponds would be so-called "blue-green" areas, or open space that is capable of filling with water during periods of high rainfall. All of these areas are now marshes or wetlands that are not easily built upon.

Also, as in Alternative Plan I, flood-plain zoning is included along the section of the stream where an existing flood plain is substantially wider than the main channel. This type of drainage planning is quite important in any area where urban development is in close proximity to open watercourses. Even if the main channel is improved to carry increased flows, it would not have the capacity to accommodate flows from maximum rainfall events.

Cost

The cost of this alternative is estimated to be $1,800,000.

PEAK FLOW COMPARISONS

The following table indicates flows with existing land use and facilities as well as with Alternative Plans I and II with projected year 2000 land use.

COMPARISON OF 10-YEAR PEAK FLOWS
(Cubic Feet Per Second)

Location	Existing Facilities	Alternative Plan I	Alternative Plan II
Juanita Bay	310	980	570
109th N.E.	180	370	50
Moulton Park	240	330	200

ENVIRONMENTAL ASSESSMENTS OF ALTERNATIVE PLANS

As part of the process of developing system proposals for the various regional basins in the RIBCO Study, field inspections were made of the suggested alternatives for each sub-basin. The inspections were made based upon the alternative evaluation procedure which identified 34 unique criteria under the general categories of 1) Effectiveness, 2) Human Values, 3) Environmental Factors, 4) Implementation, and 5) Resource Requirements. The various structural solutions were checked against the appropriate evaluation matrix criteria and the various non-structural solutions were reviewed for their relationship to existing and probable future planned development. The matrix-rating total for Alternative Plan I, which employs channelization and streambank protection througnout much of the basin, was a minus 2 on a scale ranging from a possible positive 108 to negative 108. The matrix-rating total for Alternative Plan II, which employs storage, flood-plain zoning, runoff control and some streambank protection in the lower reaches, was a plus 50.

Alternative Plan I is judged to be marginally effective in controlling drainage problems in this developing basin. Alternative Plan II provides a more positive method of controlling storm runoff and received a positive score for effectiveness. Both alternatives are generally supportive of human values but have greatly divergent environmental impact, with Alternative Plan II offering the most protection for the natural stream course, fisheries potential and water quality control. Both alternatives are judged to be equally difficult to implement and both require generally the same level of resource commitment.

The critical element in both solutions is the necessity to provide streambank protection in the lower reaches of Juanita Creek. This results from the expected high level of urbanization within the sub-basin and even under Alternative Plan II, which incorporates runoff controls, channel protection is necessary in the lower reaches to reduce or eliminate erosion.

Alternative Plan II relies upon flood-plain zoning and runoff control for future land development. This element, if it is to be part of the chosen alternative, should be implemented as an early action as any future portion of the sub-basin that develops without these controls will result in need for a more structural solution than Alternative Plan II can accommodate.

CONCLUSIONS

There still is an opportunity to preserve Juanita Creek and its tributaries in their natural condition. To do so requires the preservation of the remaining wetlands as well as an adherence to strict runoff controls from all remaining future development in the sub-basin. The prospect of saving this stream in its present condition is contingent upon immediate agreement to develop a master plan for drainage management within the sub-basin. Because King County controls 95% of this sub-basin, they should proceed to develop, in detail, the concepts incorporated in Alternative Plan II if such concepts are found to be supported by the general public within this sub-basin.

RUNOFF QUALITY SUMMARY
JUANITA CREEK

BASED UPON A 10-YEAR STORM PRECEDED BY 15 DAYS WITH LITTLE OR NO RAINFALL#

			CONCENTRATION AT PEAK FLOW*				
LOCATION	ALTERNATIVE PLAN	PEAK FLOW (cfs)	BOD	TOTAL COLIFORM	NH_3	$NO_2 + NO_3$	PO_4
	2000 Comprehensive Land Use						
Mouth of Creek	Existing Conditions	310	19	1.2×10^5	.4	1.2	.1
	I	980	21	3.6×10^5	.7	1.7	.2
	II	570	13	2.1×10^5	.3	.9	.1

Less than a total of 0.5 inches of rainfall in any one day.
* Concentrations in mg/liter except total coliform which is in MPN/100 ml.

EVALUATION MATRIX

JUANITA CREEK

	EFFECTIVENESS	Use of existing facilities	System reliability	System maintainability	System flexibility	Flood damage reduction	Consequences of overcharge	Erosion and sedimentation control	Cost/benefits ranking	HUMAN VALUES	Urban quality (aesthetics)	Effect on land use	Displacement of people	Educational value	Community cohesion	Multiple use potential	Public health and safety	ENVIRONMENTAL FACTORS	High flow conditions	Alteration of natural system	Effects on groundwater	Low flow conditions	Water quality	Construction disruption	Effects on wildlife	Effects on aquatic life	Effects on vegetation	IMPLEMENTATION	Legislative requirements	Jurisdictional	Land acquisition	Public acceptance	Financing	Effects of no action	RESOURCE REQUIREMENTS	Energy	Materials	Land	Capital	RATING TOTAL
ALTER- NATIVES	SUB TOTAL	CRITERIA WEIGHT 1	4	3	2	4	4	4	2	SUB TOTAL	CRITERIA WEIGHT 4	2	2	1	3	3	4	SUB TOTAL	CRITERIA WEIGHT 4	4	4	4	4	2	4	4	4	SUB TOTAL	CRITERIA WEIGHT 4	4	2	4	4	3	SUB TOTAL	CRITERIA WEIGHT 3	3	2	2	
I	- 3									+ 3								- 8										+4							+2					- 2
II	+20									+11								+18										-1							+2					+50

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative I Sub Basin Juanita Creek

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
1	Channel	15'	900'	1:1	4'	Channel	20' width 4' depth 1:1 side slopes With bank protection	$35,000
3	Channel	10'	1,300'	1:1	4'	Channel	20' width 4' depth 1:1 side slopes With bank protection	$52,000
4	Channel	10'	1,500'	1:1	6'	Channel	15' width 6' depth 1:1 side slopes With bank protection	$79,000
22	Culvert	42" 60"	30'			Replacement Culvert	20' x 8'	$29,000
23	Culvert	Two-42"	30'			Replacement Culvert	20' x 5'	$23,000
27	Culvert	Two-60"	30'			Replacement Culvert	20' x 5'	$23,000
8	Pipe	30"	1,100'			Parallel Pipe	24"	$46,000
58	Pipe	24"	1,700'			Parallel Pipe	21"	$51,000
20	Pipe	18"	1,500'			Parallel Pipe	18"	$45,000
73	Channel	10'	700'	1:1	6'	Channel	Streambank protection	$30,000
5	Channel	4'	700'	1:1	6'	Channel	Streambank protection	$30,000
6	Channel	3'	2,000'	1:1	6'	Channel	Streambank protection	$144,000
7	Channel	10'	800'	1:1	6'	Channel	Streambank protection	$52,000
9	Channel	10'	1,000'	5:1	6'	Channel	Streambank protection	$156,000
30	Channel	10'	1,400'	1:1	6'	Channel	Streambank protection	$61,000
32	Channel	6'	2,000'	3:1	6'	Channel	Streambank protection	$194,000
36	Channel	4'	2,000'	3:1	6'	Channel	Streambank protection	$194,000

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative I Sub Basin Juanita Creek

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
15	Channel	4'	1,000'	3:1	4'	Channel	Streambank protection	$65,000
35	Channel	4'	1,800	3:1	5.4'	Channel	Streambank protection	$157,000
53	Channel	4'	2,800'	3:1	4'	Channel	Streambank protection	$272,000
54	Channel	4'	2,300'	1:1	6'	Channel	Streambank protection	$100,000
46	Culvert	3' x 5'	30'			Parallel Culvert	42"	$2,000
47	Culvert	3' x 5'	30'			Parallel Culvert	42"	$2,000
70	Culvert	24"	30'			Parallel Culvert	Two-30"	$3,000
62	Culvert	18"	40'			Parallel Culvert	15"	$1,000
33	Culvert	42"	40'			Parallel Culvert	36"	$3,000
34	Culvert	42"	50'			Parallel Culvert	42"	$4,000
37	Culvert	42"	40'			Parallel Culvert	42"	$3,000
65	Culvert	48"	40'			Parallel Culvert	42"	$3,000
46	None					Inlet/ Outlet	For 42"	$7,000
47	None					Inlet/ Outlet	For 42"	$7,000
70	None					Inlet/ Outlet	For two-30"	$10,000
62	None					Inlet/ Outlet	For 15"	$2,000
33	None					Inlet/ Outlet	For 36"	$6,000

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative I   Sub Basin Juanita Creek

	EXISTING FACILITIES					PROPOSED FACILITIES		
ELEMENT NUMBER	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
37	None					Inlet/ Outlet	For 42"	$7,000
34	None					Inlet/ Outlet	For 42"	$7,000
65	None					Inlet/ Outlet	For 42"	$7,000

The Estimated Capital Cost for each element includes Contractor profit, engineering, legal and contingencies. In addition, land purchase and severance costs are included where land is required. All costs are based upon June 1973 prices.

Total Estimated Capital Cost: $1,912,000

Round To: $1,900,000

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative II Sub Basin Juanita Creek

ELEMENT NUMBER	EXISTING FACILITIES: TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	PROPOSED FACILITIES: TYPE		ESTIMATED CAPITAL COST
3	Channel	10'	1,300'	1:1	4'	Channel	15' width 4' depth with bank protection 1:1 side slopes	$44,000
4	Channel	10'	1,500'	1:1	6'	Channel	Streambank protection	$79,000
5	Channel	4"	700'	1:1	6'	Channel	Streambank protection	$30,000
7	Channel	10'	800'	1:1	6'	Channel	Streambank protection	$52,000
30	Channel	10"	1,400'	1:1	6'	Channel	Streambank protection	$61,000
32	Channel	6'	2,000'	3:1	6'	Channel	Streambank protection	$194,000
8	Pipe	30"	1,100'			Parallel Pipe	18"	$33,000
20	Pipe	18"	1,500'			Parallel Pipe	18"	$45,000
34	Culvert	42"	50'			Parallel Culvert	42"	$4,000
43	Culvert	42"	40'			Parallel Culvert	36"	$3,000
22	Culvert	42" 60"	30'			Replacement Culvert	12' x 5'	$20,000
23	Culvert	Two-42"	30'			Replacement Culvert	12' x 5'	$20,000
16	None					Holding Pond	1 AF in existing pond	$21,000
15	Channel	4'	1,000'	3:1	4'	Holding Pond	1 AF in existing pond	$21,000
56	None					Holding Pond	1 + AF along highway embankment	$21,000
70	Culvert					Holding Pond	.5 AF in wetlands	$37,000
25	None					Holding Pond	20 AF in Lake Whittenmeyer	$351,000

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

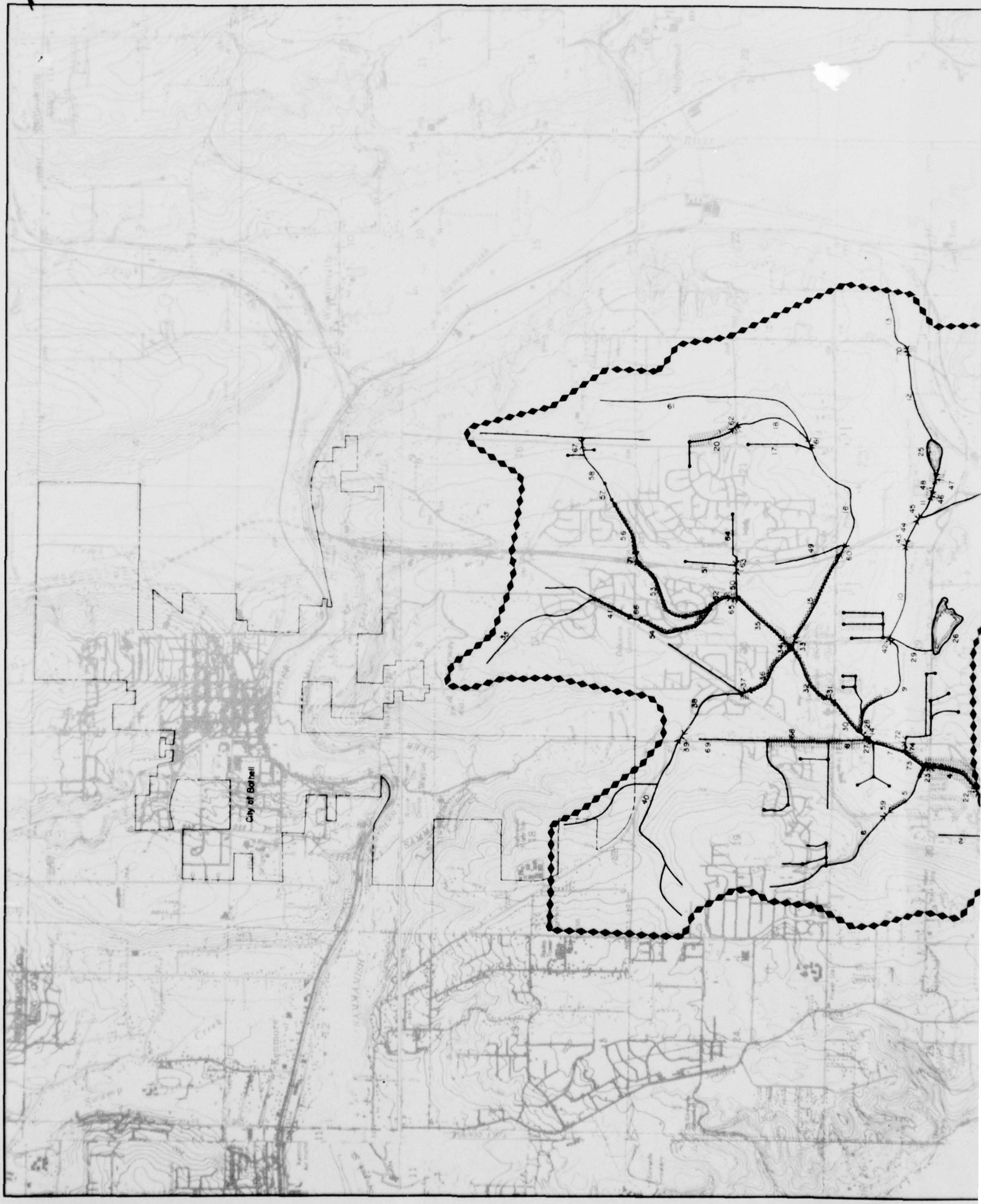
Alternative II   Sub-Basin Juanita Creek

	EXISTING FACILITIES					PROPOSED FACILITIES		
ELEMENT NUMBER	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
10	None					Holding Pond	41 AF in wetland upstream from high school	$706,000
34	Culvert					Inlet/ Outlet	For 42"	$7,000
43	Culvert					Inlet/ Outlet	For 36"	$6,000

The Estimated Capital Cost for each element includes Contractor profit, engineering, legal and contingencies. In addition, land purchase and severance costs are included where land is required. All costs are based upon June 1973 prices.

Total Estimated Capital Cost: $1,755,000

Round To: $1,800,000


City of Bothell

LEGEND

- SUB-BASIN BOUNDARY
- EXISTING CHANNEL
- EXISTING CONDUIT
- MANHOLE, INLET, OR JUNCTION
- CHANNEL OR CONDUIT DESIG. 5
- CITY LIMITS
- COUNTY (METRO) BOUNDARY
- LEVEE
- CULVERT
- HOLDING POND OR LAKE

N

1/2 1/4 0 1
MILES

1000 500 0 4000
FEET

NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

JUANITA CREEK

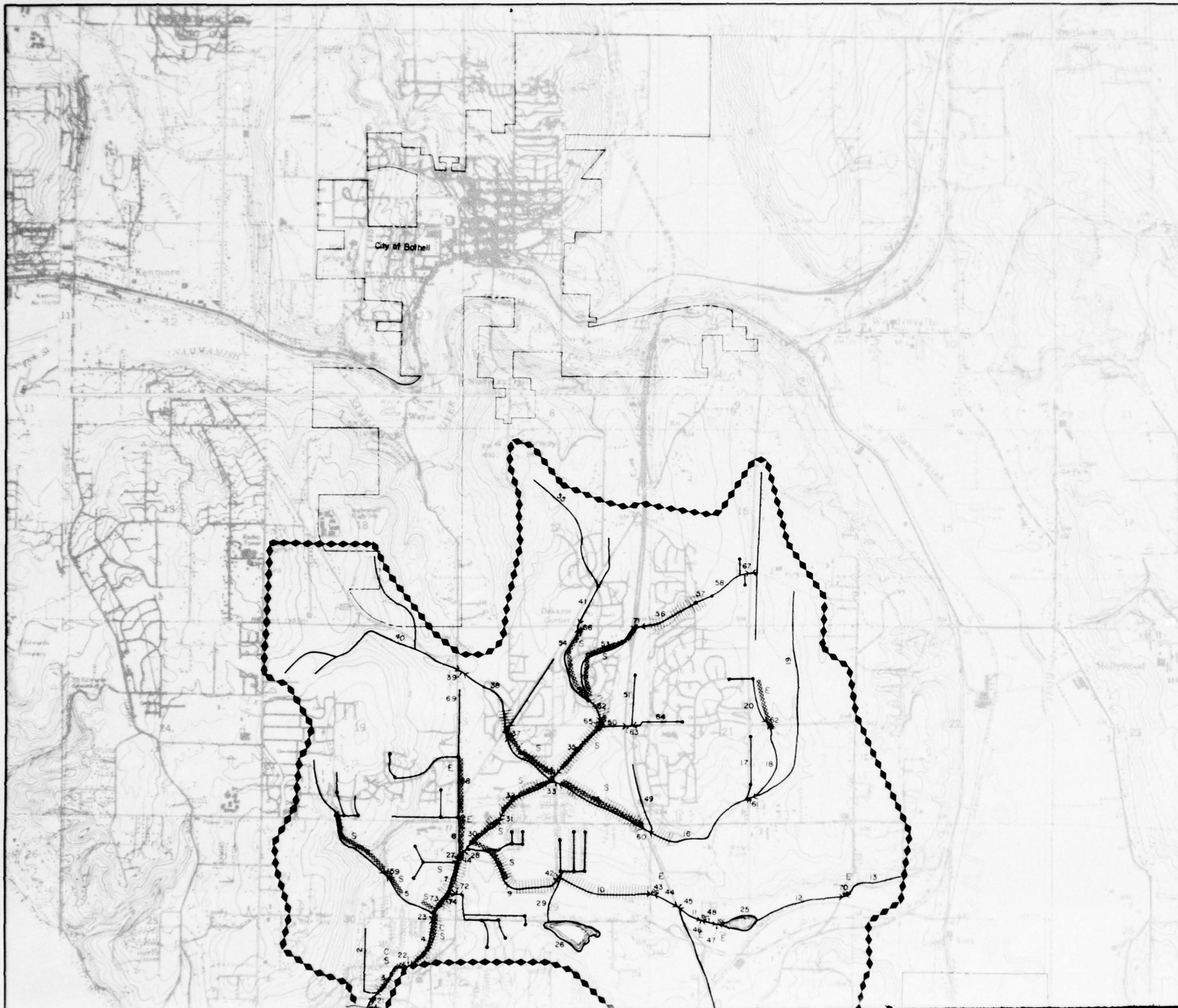
PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

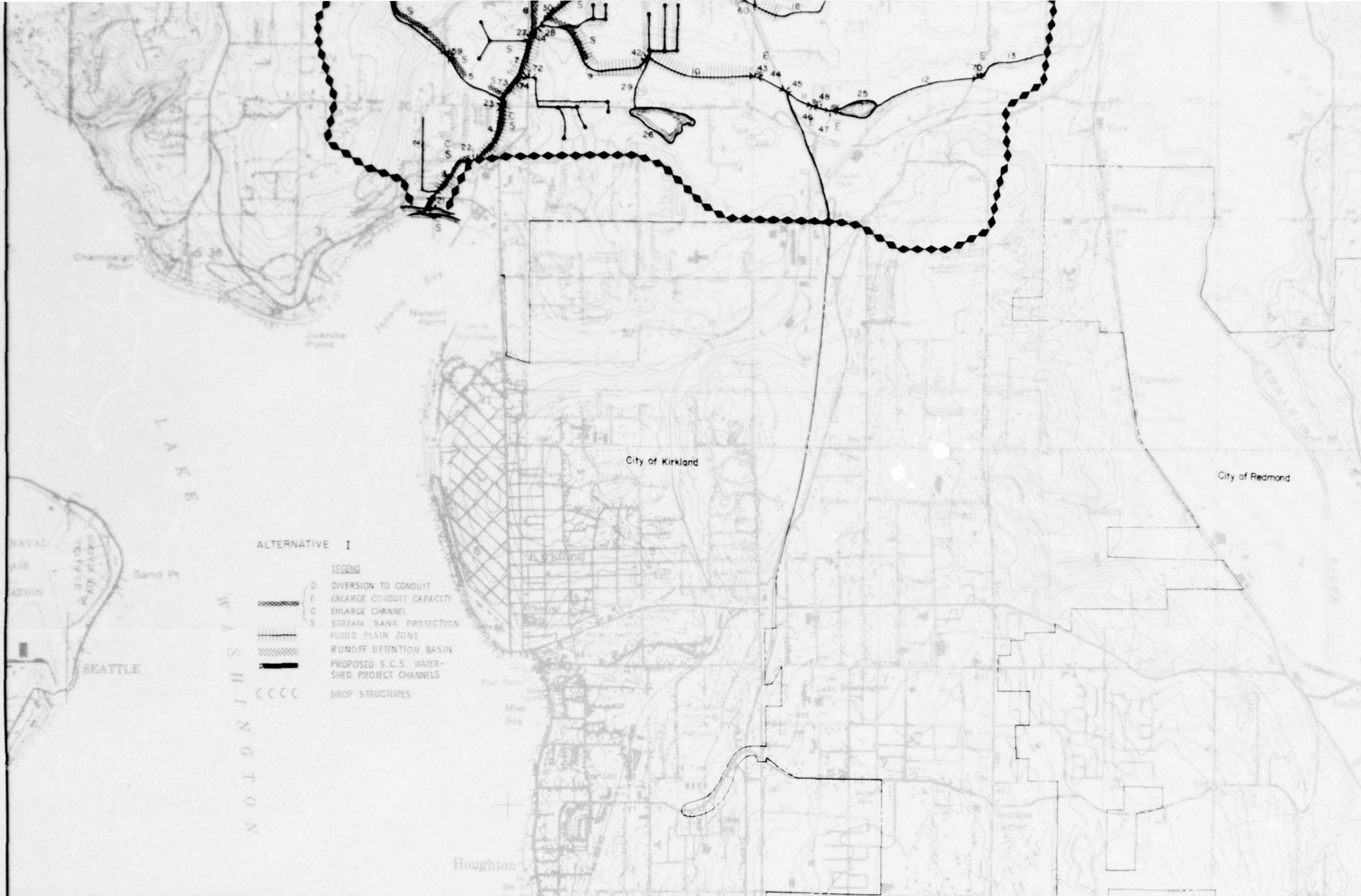
KRAMER, CHIN AND MAYO, INC.
WATER RESOURCES ENGINEERS, INC.
YODER, TROTTER, ORLOB & ASSOCIATES

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO. E-26-1-161 SHEET 1 OF 1

2


City of Bothell



LEGEND

SUB-BASIN BOUNDARY
EXISTING CHANNEL
EXISTING CONDUIT
MANHOLE, INLET, OR JUNCTION
CHANNEL OR CONDUIT DESIG. 5
CITY LIMITS
COUNTY (METRO) BOUNDARY
LEVEE

CULVERT
HOLDING POND OR LAKE

N

1/2 1/4 0 1 MILES

1000 500 0 4000 FEET

NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

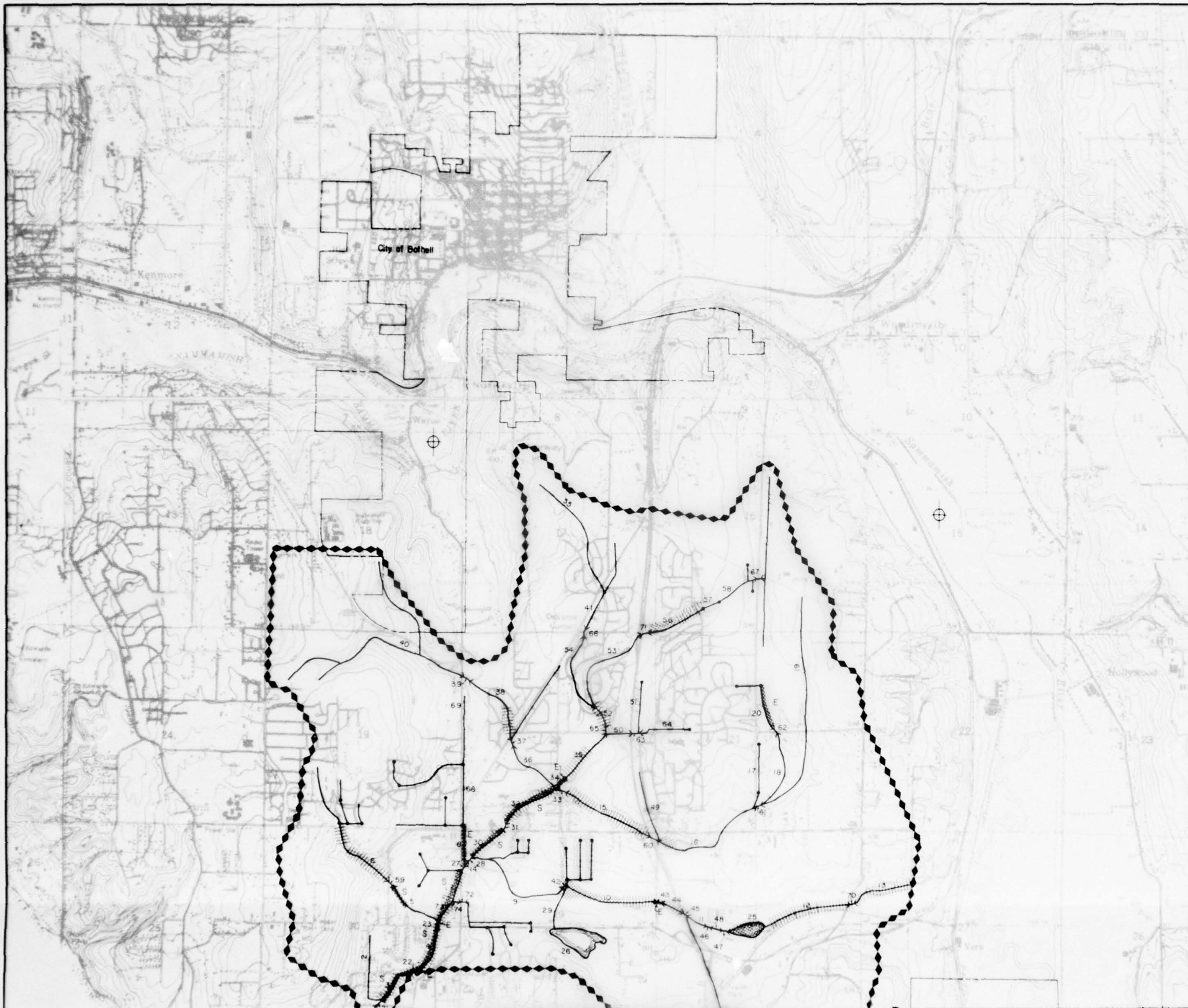
JUANITA CREEK

PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

KRAMER, CHIN AND MAYO, INC
WATER RESOURCES ENGINEERS, INC
YODER, TROTTER, ORLOB & ASSOCIATES

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO E-26-1-161 SHEET 1 OF 1



City of Bothell
Kenmore
Sammamish
River

LEGEND

- SUB-BASIN BOUNDARY
- EXISTING CHANNEL
- EXISTING CONDUIT
- MANHOLE, INLET, OR JUNCTION
- CHANNEL OR CONDUIT DESIG. 5
- CITY LIMITS
- COUNTY (METRO) BOUNDARY
- LEVEE
- CULVERT
- HOLDING POND OR LAKE

N

1/2 1/4 0 1
MILES

1000 500 0 4000
FEET

NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

JUANITA CREEK

PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

KRAMER, CHIN AND MAYO, INC
WATER RESOURCES ENGINEERS, INC
YODER, TROTTER, ORLOB & ASSOCIATES

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO E-26-1-161 SHEET [illegible] OF 1

REGIONAL SUB-BASIN C-11

LYON CREEK

GENERAL DESCRIPTION

The Lyon Creek Sub-Basin is located in the northwestern portion of the Cedar River Basin, within both King and Snohomish counties, and drains to the north end of Lake Washington. Lyon Creek, the only major watercourse in the sub-basin, has its headwaters at approximately 400 feet above mean sea level within Mountlake Terrace and Brier. The creek flows through portions of King County and Lake Forest Park before entering Lake Washington. The main channel is approximately 3.8 miles long. Approximately 20% of the sub-basin is within the Lake Forest Park corporate limits, 30% is within Mountlake Terrace, 20% within Brier, 25% in unincorporated portions of King County and 5% in Snohomish County.

Principal Streams	Category	Drainage Area	Discharge
Lyon Creek	III	3.8 sq. mi.	Lake Washington

Present land use consists primarily of single-family residential development with some undeveloped land, mainly along Lyon Creek. Future development probably will occur in much the same manner as present development; i.e., most land area will continue to be used for single-family residential purposes and limited commercial development.

The table below shows the percentages of land uses by type for the Lyon Creek Sub-Basin during 1970-72 and projected for the year 2000 Corridor Plan and Comprehensive Plan by the Puget Sound Governmental Conference.

PERCENT OF SUB-BASIN AREA IN SPECIFIED LAND USE

Land Use	Existing (1970-72)	P.S.G.C. Land Use Projection Comprehensive	Corridor
Single Family	45	68	61
Multiple Family		5	9
Commercial/Services	3	5	8
Govt. and Educ.	7	7	7
Industrial			
Parks/Dedicated Open Space	8	5	12

Land Use	Existing (1970-72)	P.S.G.C. Land Use Projection Comprehensive	Corridor
Agriculture		8	
Airports, Railyards, Freeways, Highways	2	2	2
Unused Land	35		1
Total	100	100	100
Total Impervious Area	30	35	35

NATURE OF EXISTING DRAINAGE SYSTEM

The main feature of the existing drainage system is Lyon Creek. As the sub-basin has developed, conventional storm drainage systems have been installed in the municipalities and county areas along the creek; all of these systems drain directly to Lyon Creek. The increased runoff rates brought about by increases in impervious area and the installation of storm drainage systems have affected the creek significantly. Some culverts under roadways are not adequate to carry existing flows without ponding, and erosion and sedimentation are evident in several locations along the main creek channel. Nevertheless, the creek is still a pleasant urban amenity in most locations. It forms an integral part of Terrace Creek Park in Mountlake Terrace. Several sections have been used to enhance yard landscaping by private property owners, and despite the substantial development in the sub-basin as a whole, the creek channel itself has not been severely encroached upon by landfilling or structures. In some places, such as along the upper east tributary in Mountlake Terrace, somewhat natural swamps and wetlands still exist and function to reduce runoff rates to downstream portions of the creek.

DRAINAGE PROBLEMS

Several minor drainage problems exist at locations throughout the sub-basin where storm drainage systems are inadequate. However, most of the major drainage problems in the basin are along lower Lyon Creek within Lake Forest Park. In these sections, the effects of upstream increases in runoff are most noticeable. The Lake Forest Park City staff has observed ponding at several roadway culverts, and erosion, sedimentation and debris accumulation in the lower reaches of the creek channel. Also, a significant sediment deposition has developed at the lakeshore as a result of upstream erosion.

Both the 2000 Comprehensive and Corridor land use plans indicate a general urbanization of Lyon Creek with a large percentage of single-family residential development. These increases in impervious areas and higher

runoff will definitely increase the severity of existing problems along Lyon Creek. The effects of stream-side land use modifications will be especially significant. If the remaining wetlands are replaced with impervious surfaces, the effects on lower Lyon Creek will be substantial. Certain lower sections of the creek have already been rip-rapped, but erosion and flooding will become worse as the sub-basin develops further, unless drainage improvements are implemented.

The results of hydrologic analysis indicate no significant difference between the comprehensive and corridor land use plans. Therefore, the drainage alternatives presented herein are applicable to both plans.

BASIC ISSUES AND STATUS OF DRAINAGE PLANNING

The only existing drainage plan in the sub-basin is one prepared by the City of Mountlake Terrace. The emphasis of this plan is upon channelization and green-belt development of upper Lyon Creek, and replacement of undersized storm drainage facilities to decrease the frequency of ponding. Full implementation of this plan, without provision for runoff control, will result in significantly higher runoff rates along lower Lyon Creek thereby compounding existing problems.

The initial alternative plans for the Lyon Creek Sub-Basin were developed after consultation with staff members from the King County Public Works Department, Hydraulic Division, the Mountlake Terrace City Engineering Department, and Snohomish County Public Works Department.

ALTERNATIVE PLANS FOR PROPOSED DRAINAGE CONTROL

The existing drainage system of Lyon Creek Sub-Basin, as described by local agencies was evaluated by computer simulation that supplied the region's 10-year storm to the year 2000 land use. Drainage problems thus identified were analyzed and possible solutions were provided in development of alternative plans for drainage control as described below.

Three major alternative plans were studied for solving Lyon Creek drainage problems, the first using culvert enlargement and stream-bank protection and the second and third being combinations of the above plus runoff control features. Their description follows:

ALTERNATIVE PLAN I

General Concept

The general concept of Alternative Plan I is to increase the capacity of the drainage system by enlarging culverts, installing parallel culverts and protecting the streambanks with rip-rap. This alternative would relieve all existing flow constraints, thereby increasing peak runoff. Control of runoff from future development would not be required.

Major Features

The major features of this alternative are culvert enlargement and streambank protection along Lyon Creek and its tributaries. In most cases, culvert capacity was enlarged by the addition of culverts parallel to the existing system; however, in some locations existing facilities were replaced with new culverts.

A majority of the culvert replacement and additions will take place in the lower reaches of the Lyon Creek Sub-Basin near Lake Forest Park. The streambank protection will be required throughout the entire sub-basin.

Cost

The total of major stream improvements is estimated at $400,000.

ALTERNATIVE PLAN II

General Concept

Alternative Plan II would make use of upstream holding ponds to reduce runoff rates throughout the sub-basin. The existing conduits and watercourses will continue to be used for drainage with little or no modification. This alternative is not dependent upon runoff control legislation in the future.

Major Features

Alternative Plan II provides for use of four holding ponds on the upper reaches of the Lyon Creek drainage system and a diversion of flow in lower Lyon Creek. The holding ponds are designed to reduce runoff throughout the sub-basin and the diversion is designed to carry the increased stream volume on the lower creek without disrupting the existing natural stream configuration.

Recreational uses of public open space, among other alternative land uses, would be compatible with this system as would be the existing use of the creek in residential landscapes.

The holding ponds would provide a total of 5.4 acre feet of storage. The facilities would control discharge to a lower rate than would be experienced from the stream in an unimpeded condition during major storms, and would hold water for release at a later time. The holding ponds also provide limited groundwater recharge.

Cost

The total estimated capital cost for this alternative is $600,000.

ALTERNATIVE PLAN III

General Concept

Alternative Plan III requires on-site runoff controls for all future development. The open watercourse of the sub-basin would be preserved and enhanced by controlling flows along the stream in accord with the runoff controls.

Major Features

Alternative Plan III would provide the same structures as Alternative Plan II except that the diversion of lower Lyon Creek would require a much smaller installation because of the reduced runoff. The four holding ponds in the upper sub-basin would require the same installation as in Alternative Plan II.

This alternative is very compatible with recreational or public use of open space as well as other alternative land uses and does not influence the creek's use as a residential landscape feature.

As in Alternative Plan II, the holding pond facilities would control discharge to a lower rate than would be experienced from the stream in an unimpeded condition during major storms, and hold water for release at a later time. The holding ponds also provide limited groundwater recharge.

Cost

The total estimated capital cost for this alternative is $400,000.

PEAK FLOW COMPARISONS

The following table indicates 10-year peak flows with existing facilities and land use and with alternative drainage management solutions for the year 2000.

COMPARISON OF 10-YEAR PEAK FLOWS
(Cubic Feet Per Second)

Location	Existing Facilities	Alternative Plan I	Alternative Plan II	Alternative Plan III
Lake Washington	370	580	200	200
Ballinger Way	230	400	170	170
Cedar Way	140	150	70	40

ENVIRONMENTAL ASSESSMENTS OF ALTERNATIVE PLANS

As part of the process of developing system proposals for the various regional basins in the RIBCO Study, field inspections were made to determine the compatibility of suggested alternatives for each sub-basin. The inspections were based upon the alternative-evaluation procedure which identified 34 unique criteria under the general categories of 1) Effectiveness, 2) Human Values, 3) Environmental Factors, 4) Implementation, and 5) Resource Requirements. The various structural solutions were checked against the appropriate evaluation-matrix criteria and the various non-structural solutions were reviewed for the their relationship to existing and probable future developments. The matrix rating for Alternative Plan I, which employs increased stream capacity together with streambank protection, was a minus 36 on a scale ranging from a positive 108 to negative 108. The evaluation rating total for Alternative Plan II, which employs holding ponds, lower creek diversion and no runoff control, was a plus 8 and the rating total for Alternative Plan III, which employs holding ponds and diversion of the lower creek together with on-site runoff control for all future development, was a plus 11.

All three systems were judged to be effective for controlling drainage and each system requires certain sacrifices of human values because of construction. Environmentally, Alternative Plans II and III clearly offer more preservation potential than Alternative Plan I which required rip-rap protection along a great percentage of the stream length including extensive work in residential areas. None of the alternatives are currently planned by any of the concerned governing agencies and extensive inter-agency action will be necessary before any of the alternatives can be implemented. All of the alternatives involve commitments of natural resources as they rely upon certain structural elements for all or part of the solution; however, Alternative Plans II and III have a slight advantage in this area.

CONCLUSIONS

Because of the residential and relatively natural nature of this basin, Alternative Plans II and III are clearly superior to Alternative Plan I. Because of the high cost of Alternative Plan II, it appears that Alternative Plan III is the most feasible; however, it does require immediate action to assure on-site runoff control for all future development.

All five agencies: Mountlake Terrace, Brier, Lake Forest Park, Snohomish County and King County should work towards agreement for development of a master plan that incorporates the provision of Alternative Plan III and all five within their own jurisdictions should immediately move toward implementing and enforcing runoff controls.

RUNOFF QUALITY SUMMARY
LYON CREEK

BASED UPON A 10-YEAR STORM PRECEDED BY 15 DAYS WITH LITTLE OR NO RAINFALL#

LOCATION	ALTERNATIVE PLAN	PEAK FLOW (cfs)	CONCENTRATION AT PEAK FLOW*				
			BOD	TOTAL COLIFORM	NH_3	$NO_2 + NO_3$	PO_4
	2000 Comprehensive Land Use						
Mouth of Creek	I	580	11	3.0×10^5	.3	.9	.1
	II	410**	10	3.0×10^5	.3	.8	.1
	III	360**	14	3.8×10^5	.4	1.0	.1

Less than a total of 0.5 inches of rainfall in any one day.
* Concentrations in mg/liter except total coliform which is in MPN/100 ml.
** Combined peak flow for channel and diversion pipe.

EVALUATION MATRIX

LYON CREEK

	EFFECTIVENESS	Use of existing facilities	System reliability	System maintainability	System flexibility	Flood damage reduction	Consequences of overcharge	Erosion and sedimentation control	Cost/benefits ranking	HUMAN VALUES	Urban quality (aesthetics)	Effect on land use	Displacement of people	Educational value	Community cohesion	Multiple use potential	Public health and safety	ENVIRONMENTAL FACTORS	High flow conditions	Alteration of natural system	Effects on groundwater	Low flow conditions	Water quality	Construction disruption	Effects on wildlife	Effects on aquatic life	Effects on vegetation	IMPLEMENTATION	Legislative requirements	Jurisdictional	Land acquisition	Public acceptance	Financing	Effects of no action	RESOURCE REQUIREMENTS	Energy	Materials	Land	Capital	RATING TOTAL
ALTER-NATIVES	SUB TOTAL	CRITERIA WEIGHT								SUB TOTAL	CRITERIA WEIGHT							SUB TOTAL	CRITERIA WEIGHT									SUB TOTAL	CRITERIA WEIGHT						SUB TOTAL	CRITERIA WEIGHT				
		1	4	3	2	4	4	4	2		4	2	2	1	3	3	4		4	4	4	4	4	2	4	4	4		4	4	2	4	4	3		3	3	2	2	
I	+ 8									-8								-18										-10							-8					-36
II	+ 4									0								+14										-12							+2					+ 8
III	+11									0								+10										-12							+2					+11

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative I　　Sub-Basin Lyon Creek

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
4	Culvert	72"	40'			Parallel Culvert	48"	$4,000
9	Culvert	3.5'	300'	0	3'	Replacement Culvert	72"	$45,000
43	Culvert	72"	45'			Parallel Culvert	60"	$5,000
15	Culvert	48"	60'			Parallel Culvert	60"	$7,000
47	Culvert	48"	60'			Parallel Culvert	36"	$4,000
62	Culvert	36"	100'			Parallel Culvert	24"	$4,000
39	Culvert	3'	100'	0	2'	Parallel Culvert	30"	$5,000
57	Culvert	3.5'	80'	0	2.5'	Replacement Culvert	4' x 3'	$11,000
8	Channel	10'	300'	4:1	3'	Channel	18' width 3' depth 300' streambank protect. 4:1 side slopes	$9,000
3	Channel						700' streambank protection	$18,000
5	Channel						800' streambank protection	$21,000
7	Channel						1000' streambank protection	$26,000
10	Channel						600' streambank protection	$15,000
24	Channel						400' streambank protection	$11,000
26	Channel						700' streambank protection	$18,000
14	Channel						1000' streambank protection	$26,000
16	Channel						1000' streambank protection	$26,000

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative I Sub Basin Lyon Creek

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
35	Channel						300' streambank protection	$8,000
48	Channel						300' streambank protection	$8,000
49	Channel						300' streambank protection	$8,000
66	Channel						600' streambank protection	$15,000
17	Channel						900' streambank protection	$23,000
58	Channel						200' streambank protection	$5,000
59	Channel						500' streambank protection	$13,000
53	Channel						1000' streambank protection	$26,000
4	None					Inlet/ Outlet	For 48"	$8,000
43	None					Inlet/ Outlet	For 60"	$10,000
15	None					Inlet/ Outlet	For 60"	$10,000
47	None					Inlet/ Outlet	For 36"	$6,000
62	None					Inlet/ Outlet	For 24"	$4,000
39	None					Inlet/ Outlet	For 30"	$5,000
9	None					Inlet/ Outlet	For 72"	$12,000

The Estimated Capital Cost for each element includes Contractor profit, engineering, legal and contingencies. In addition, land purchase and severance costs are included where land is required. All costs are based upon June 1973 prices.

Total Estimated Capital Cost: $416,000
Round To: $400,000

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative II Sub-Basin Lyon Creek

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
22	None					Holding Pond	2.8 AF	$15,000
55	None					Holding Pond	1.0 AF	$30,000
40	None					Holding Pond	1.1 AF	$30,000
26	None					Holding Pond	0.5 AF	$22,000
70	None					Diversion Pipe	42" 6,800'	$535,000

The Estimated Capital Cost for each element includes Contractor profit, engineering, legal and contingencies. In addition, land purchase and severance costs are included where land is required. All costs are based upon June 1973 prices.

Total Estimated Capital Cost: $632,000

Round To: $600,000

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

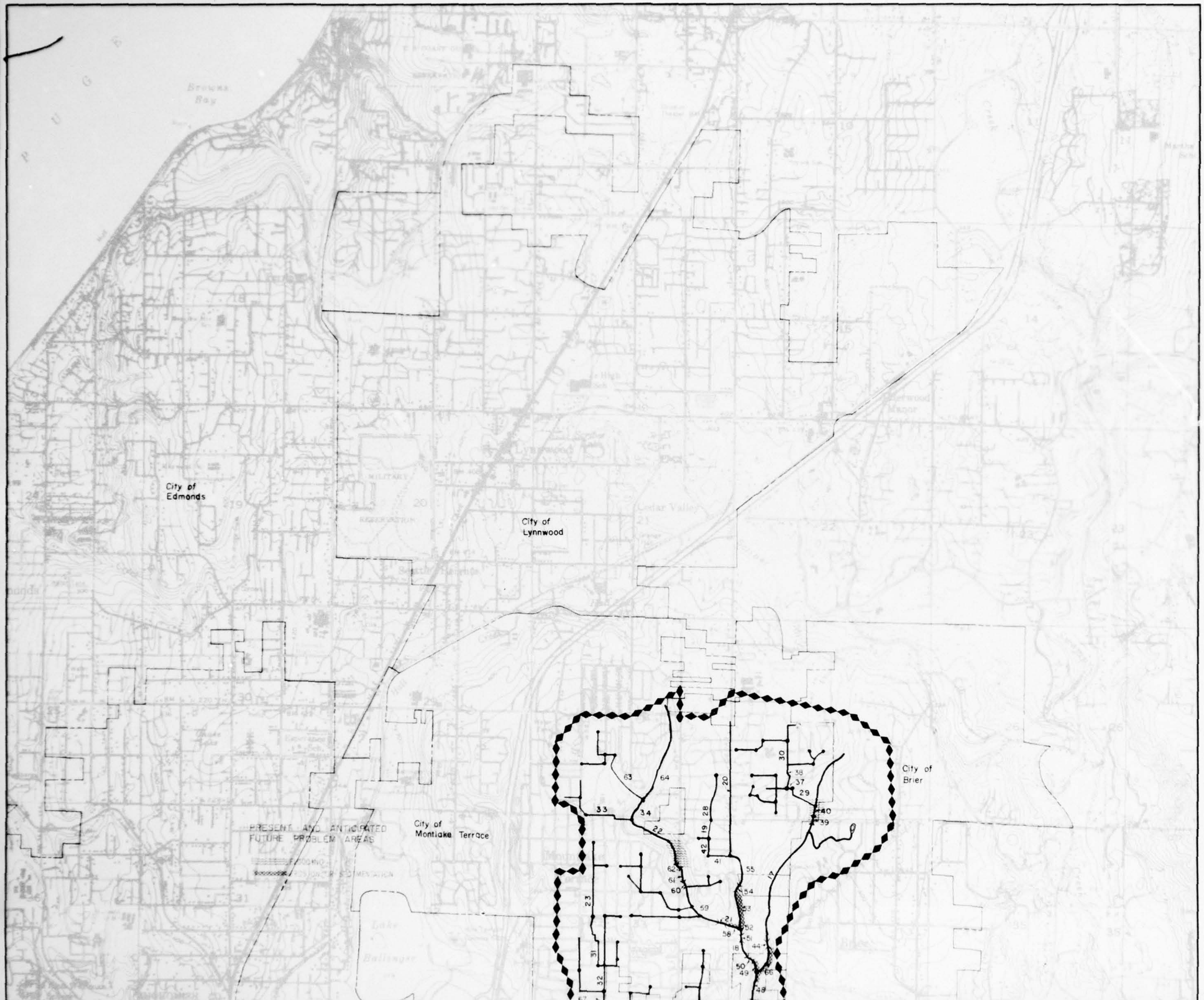
Alternative III Sub-Basin Lyon Creek

	EXISTING FACILITIES					PROPOSED FACILITIES		
ELEMENT NUMBER	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
22	None					Holding Pond	2.8 AF	$15,000
55	None					Holding Pond	1.0 AF	$30,000
40	None					Holding Pond	1.1 AF	$30,000
26	None					Holding Pond	0.5 AF	$22,000
70	None					Diversion Pipe	24" 6,800'	$286,000

The Estimated Capital Cost for each element includes Contractor profit, engineering, legal and contingencies. In addition, land purchase and severance costs are included where land is required. All costs are based upon June 1973 prices.

Total Estimated Capital Cost: $383,000

Round To: $400,000



City of Edmonds
City of Lynnwood
City of Brier
City of Montlake Terrace
PRESENT AND ANTICIPATED FUTURE PROBLEM AREAS

NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

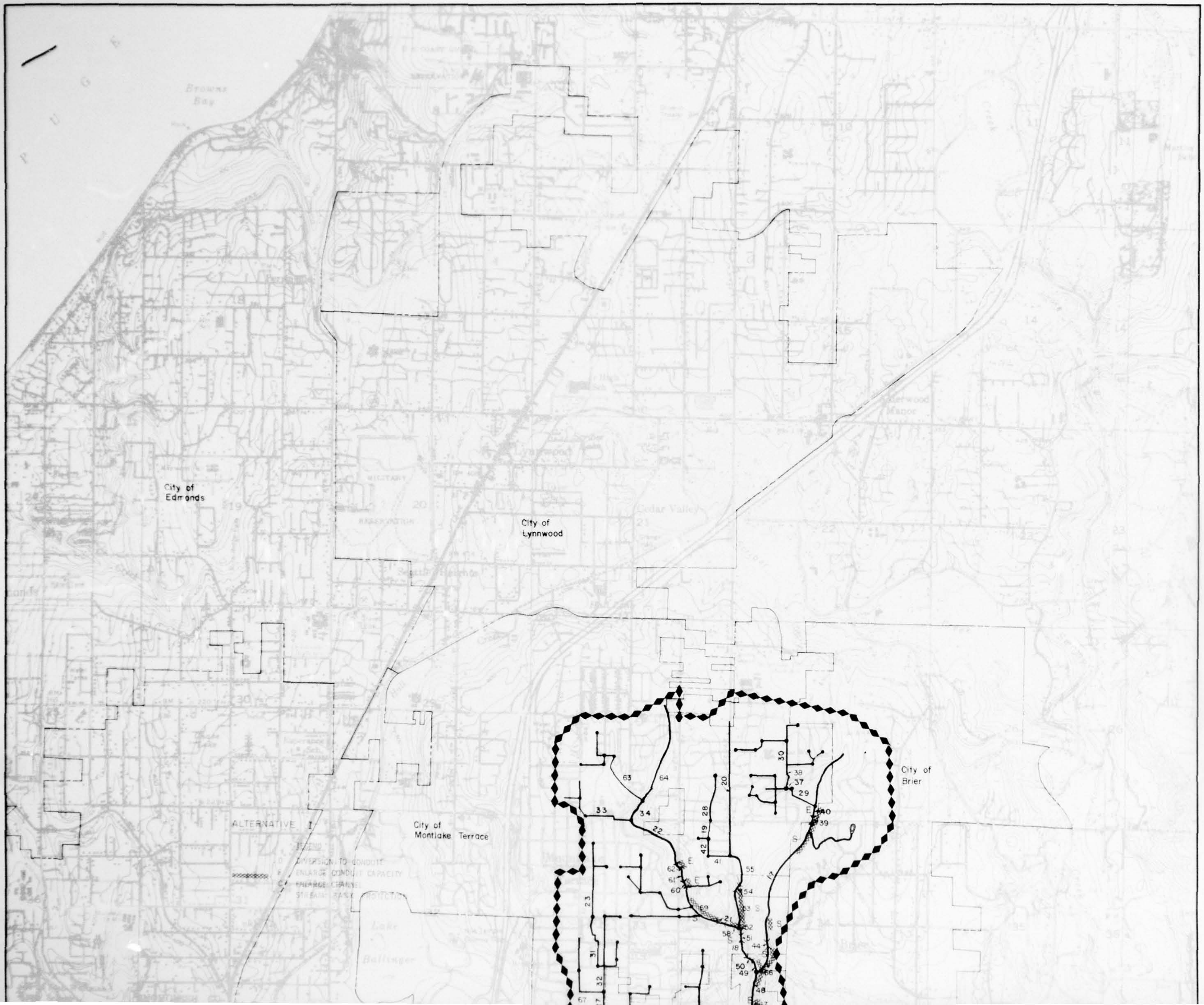
LYON CREEK

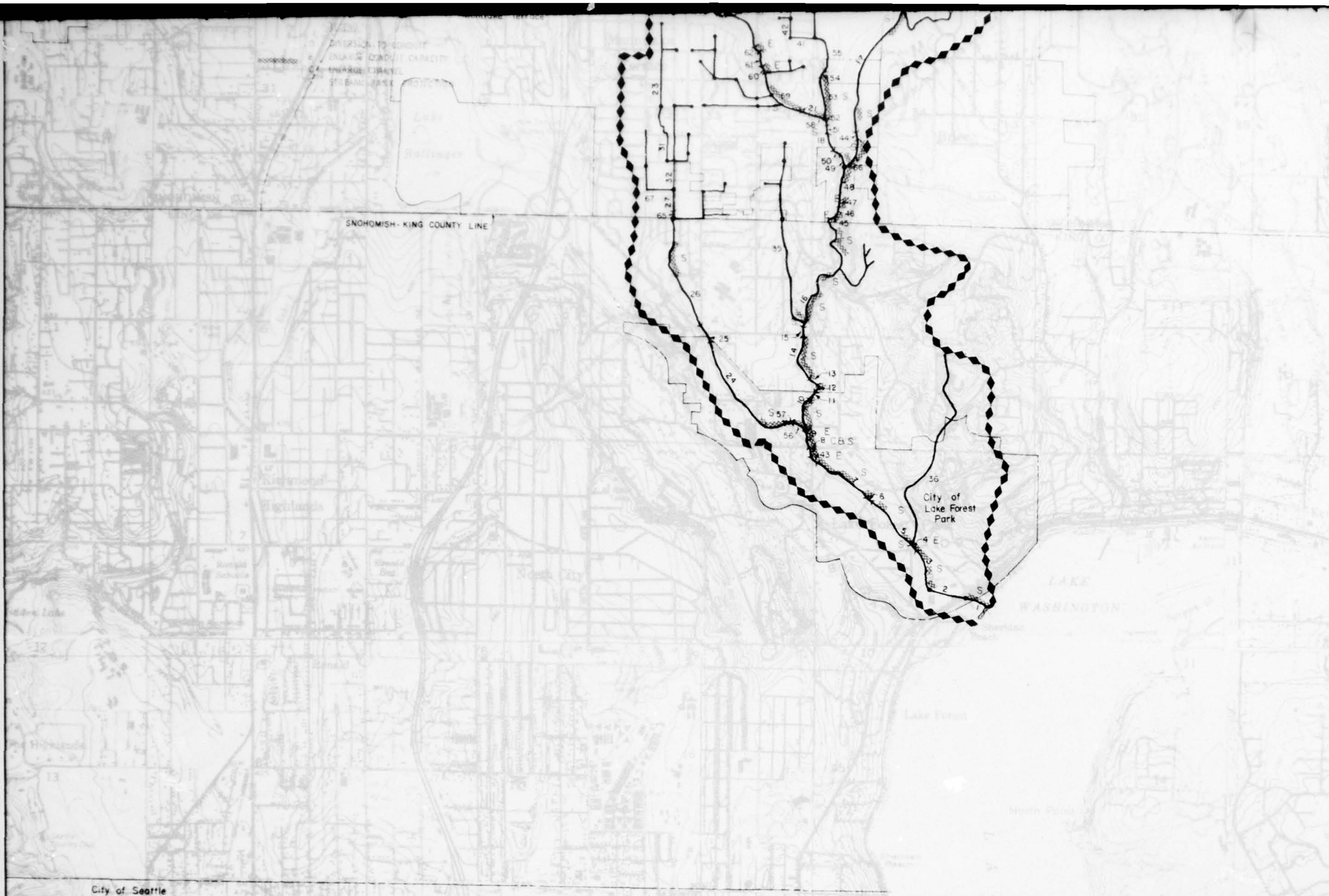
PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF *THE RIVER BASIN COORDINATING COMMITTEE (RIBCO)* AND THE METRO COUNCIL

KRAMER, CHIN AND MAYO, INC WATER RESOURCES ENGINEERS, INC YODER, TROTTER, ORLOB & ASSOCIATES	U.S. ARMY ENGINEER DISTRICT, SEATTLE CORPS OF ENGINEERS SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO E-26-1-161 SHEET 1 OF 1

2


City of Edmonds
City of Lynnwood
City of Montlake Terrace
City of Brier
ALTERNATIVE I
LEGEND
D DIVERSION TO CONDUIT
E ENLARGE CONDUIT CAPACITY
C ENLARGE CHANNEL
S STREAMBANK PROTECTION



LEGEND

- SUB-BASIN BOUNDARY
- EXISTING CHANNEL
- EXISTING CONDUIT
- MANHOLE, INLET, OR JUNCTION
- CHANNEL OR CONDUIT DESIG. 5
- CITY LIMITS
- COUNTY (METRO) BOUNDARY
- LEVEE
- CULVERT
- HOLDING POND OR LAKE

N

MILES: 1/2, 1/4, 0, 1

FEET: 1000, 500, 0, 4000

NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

LYON CREEK

PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

TRAMER, CHIN AND MAYO, INC
WATER RESOURCES ENGINEERS, INC
YODER, TROTTER, ORLOB & ASSOCIATES

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO E-26-1-161 SHEET 1? OF 1

2

AD-A042 166 KCM-WRE/YTO SEATTLE WASH F/G 8/8

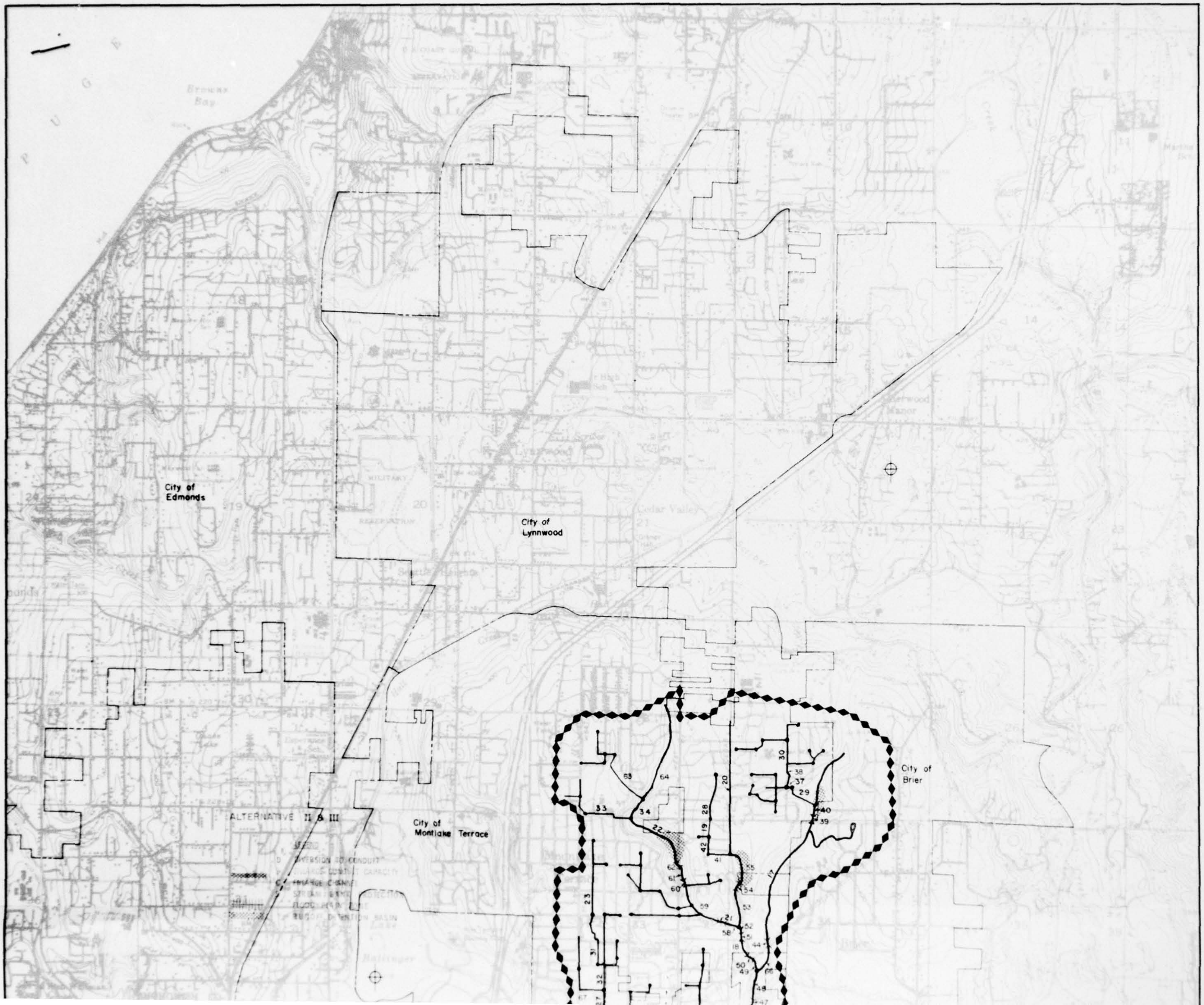
ENVIRONMENTAL PLANNING FOR THE METROPOLITAN AREA CEDAR-GREEN RI--ETC(U)

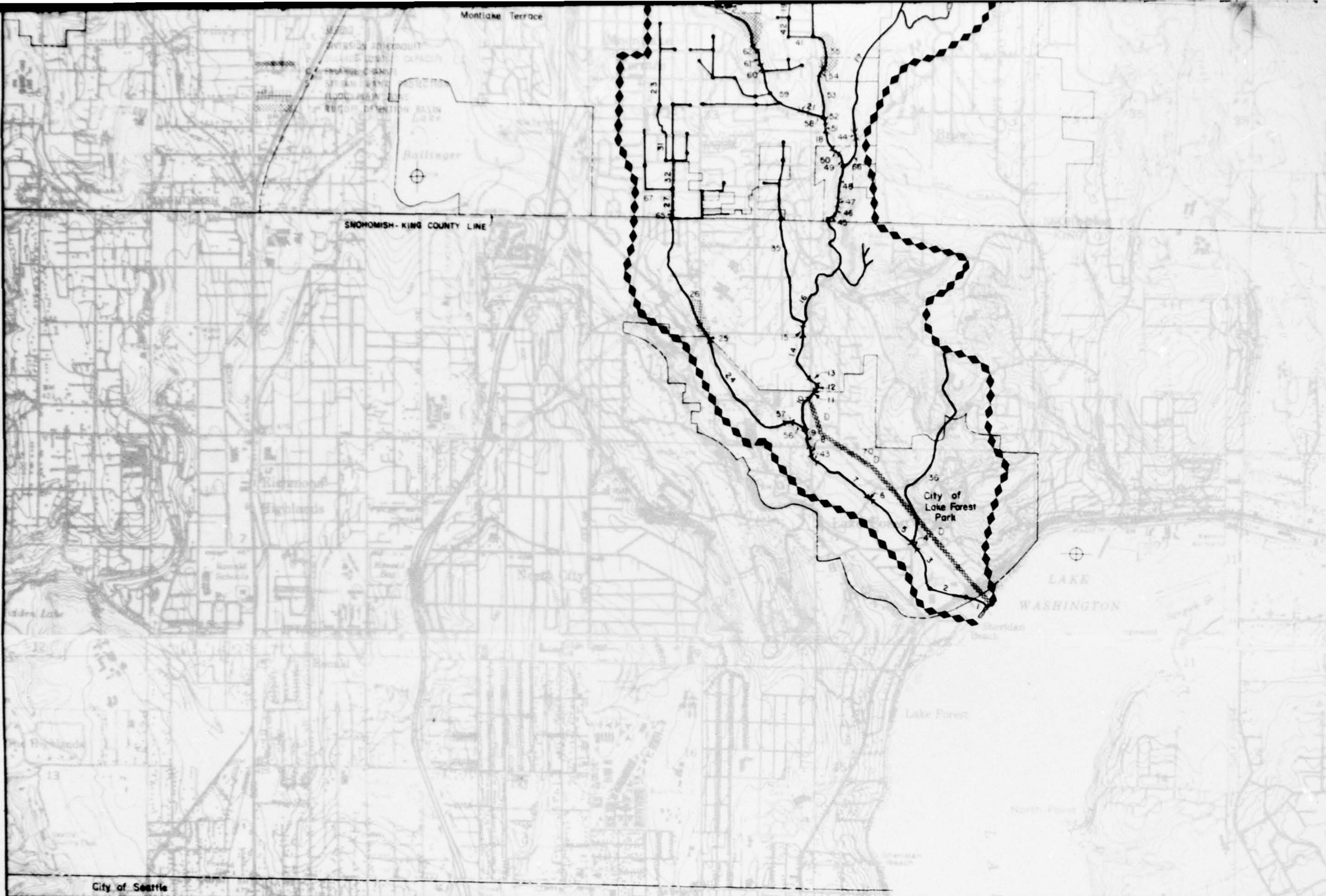
DEC 74 DACW67-73-C-0022

UNCLASSIFIED NL

4 OF 6

AD A042166


City of Edmonds
City of Lynnwood
City of Montlake Terrace
City of Brier
ALTERNATIVE II & III



LEGEND

SUB-BASIN BOUNDARY
EXISTING CHANNEL
EXISTING CONDUIT
MANHOLE, INLET, OR JUNCTION
CHANNEL OR CONDUIT DESIG. 5
CITY LIMITS
COUNTY (METRO) BOUNDARY
LEVEE

CULVERT
HOLDING POND OR LAKE

N

1/2 1/4 0 1 MILES

1000 500 0 4000 FEET

NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

LYON CREEK

PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

KRAMER, CHIN AND MAYO, INC
WATER RESOURCES ENGINEERS, INC
YODER, TROTTER, ORLOB & ASSOCIATES

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO E-26-1-161 SHEET 10 OF 1

REGIONAL SUB-BASIN C-12

McALEER CREEK

GENERAL DESCRIPTION

McAleer Creek is northwest of Lake Washington in the Cedar River Basin. The sub-basin's northern boundary is Lynnwood. The eastern boundary is approximately at the center of Mountlake Terrace. The western boundary is in Edmonds and the sub-basin drains through Lake Forest Park before it enters Lake Washington.

The topography of the sub-basin is moderately sloping uplands draining to a narrow valley. The headwaters of the sub-basin is Hall Lake at elevation 330 feet. The stream outlet elevation is 15 feet at Lake Washington.

The principle streams are Hall Cre[illegible]roximately two miles long, which drains Hall Lake into Lake Bal[illegible] and McAleer Creek, approximately three and one-half miles long, [illegible]t drains Lake Ballinger into Lake Washington. Chase Lake and Echo Lake are other lakes of significance in the sub-basin.

Stream	Category	Drainage Area	Discharge
Hall Creek	III	3.6 sq. mi.	Lake Ballinger
McAleer Creek	III	8.0 sq. mi.	Lake Washington

The sub-basin is highly developed at this time. The major land-use activity is single-family residential. At present, McAleer Creek except at its mouth is not significantly encroached upon because it is in the bottom of a steep gully that prevents building immediately adjacent to the creek. The area north and east of Lake Ballinger is used for a park and a golf course. Lake Ballinger is a water recreation center for abutting residences and the general public via the public-park area.

The table below shows the percentage of land use by types for the McAleer Creek Sub-Basin as of 1970-72 and those projected for the year 2000 in the Corridor and Comprehensive plans proposed by the Puget Sound Governmental Conference. It should be noted that the increased use for residential purposes will come to presently unused lands.

PERCENT OF SUB-BASIN AREA IN SPECIFIED LAND USE

Land Use	Existing (1970-72)	P.S.G.C. Land Use Projection Comprehensive	Corridor
Single Family	72	57	51
Multiple Family		10	15
Commercial/Services	5	8	8
Govt. and Educ.	1	3	2
Industrial		5	7
Parks/Dedicated Open Space	10	15	15
Agriculture			
Airports, Railyards, Freeways, Highways	1	1	1
Unused Land	10		
Water	1	1	1
Total	100	100	100
Total Impervious Area	30	40	40

Future development trends consist of utilizing the remaining vacant land for residential and park activity and conversion of existing single-family residential land to higher density residential, commercial and industrial uses.

Agencies within McAleer Creek Sub-Basin that have drainage responsibility are, by approximate area within the sub-basin, Mountlake Terrace 25%, King County 25%, Edmonds 23%, Lynnwood 22%, Snohomish County 3%, and Lake Forest Park 2%.

McAleer Creek was studied by the WASH-USE-1 program of Snohomish County, so attention was focused upon it by the jurisdictions involved.

The City of Mountlake Terrace has taken an especially active interest in Lake Ballinger as it intends to use the area to the north as a city park. The City of Edmonds also has taken an active interest in correcting Lake Ballinger's problems. Citizen concern for Lake Ballinger has been voiced by the Lake Ballinger Community Club.

NATURE OF EXISTING DRAINAGE SYSTEM

The existing Hall Creek stream system has been channelized somewhat and plans exist for additional modifications. McAleer Creek basically is in a natural condition. Lake Ballinger is controlled to an adjudicated level of 278 feet.

The cities of Lynnwood, Edmonds and Mountlake Terrace have constructed a number of storm-drainage facilities that lead to Hall Creek, Lake Ballinger, and McAleer Creek. King County also has storm drained the Echo Lake area which now flows into Lake Ballinger.

The major drainage-system element with urban value is Lake Ballinger with a park area providing access to the lake. The City of Mountlake Terrace is considering the allowance of boating and swimming in their park area. McAleer Creek does support salmon runs and any activity in the creek is of interest to the Department of Fisheries.

DRAINAGE PROBLEMS

The major drainage problems of the McAleer Creek Sub-Basin are located at Lake Ballinger and below Interstate Highway 5. They consist of stream and lake flooding, area ponding, erosion and sedimentation. These result from upstream watershed development.

Hall Creek apparently does not now have major flooding problems. The level of Lake Ballinger fluctuates significantly and this causes flooding of adjacent property on the north and south ends, including the Mountlake Terrace Golf Course (north end of the lake). Erosion of channel banks leading to the lake and erosion of the lake frontage also is appearing. Erosion of the inlet channel is caused by high flows while the lake frontage erosion is caused by wave action at high lake levels.

Erosion of streambanks occurs in the lower portion of McAleer Creek below I-5 and this material is deposited at the lower end of the stream before it enters Lake Washington. Some flooding of the lower stream section has been reported and the culvert under Bothell Way and the three downstream bridges are reported to be undersize.

The area surrounding Chase Lake is experiencing water quality and drainage problems because of excessive septic tank failures coincidental with a high water table. The coliform count of Lake Ballinger has been tested and the suitability of the lake for body contact is being surveyed. This condition is of concern to Mountlake Terrace residents because of plans for a park there. Lake Ballinger also has been discolored by erosion from adjacent land.

Further development in the sub-basin will overtax the streams and increase water pollution caused by urban runoff. Various storm

drains within Mountlake Terrace and Edmonds are predicted to be inadequate to handle future peak flows. The erosion of McAleer Creek will accelerate and increased flooding will occur near Bothell Way and along the stream between Bothell Way and Lake Washington.

Significant flow differentials exist between the 2000 Comprehensive and 2000 Corridor land use plans, therefore both plans were investigated. The Comprehensive land-use plan indicates higher flows in Hall Creek than the Corridor Plan. The Corridor plan indicates higher flows in the lower portion of the watershed than the Comprehensive plan. The total outflow at Lake Washington for the two plans is identical. The same type of problems were indicated by both land-use plans, only severity of the problems differed.

BASIC ISSUES AND STATUS OF DRAINAGE PLANNING

Many political agencies in the basin have formulated drainage plans for their areas. Mountlake Terrace has prepared a channelization plan for Hall Creek that calls for stream clearing, rip-rap and channel modifications. Road culverts also would be increased in size to accommodate the increased runoff under saturation development. King County and Snohomish County have cooperated in the preparation of a plan for channelizing the outlet of Lake Ballinger. The project has not been implemented. King County and Lake Forest Park have not prepared plans for the section of the stream in their jurisdictions. Snohomish County, in their WASH-USE-1 study investigated the upper portion of the watershed but did not recommend a specific plan and did not consider downstream effects in King County.

As part of the RIBCO planning effort, numerous public meetings were held throughout the Cedar and Green River Basins to obtain public input for local problems and concerns. Engineering alternatives were presented in these meetings and comments were solicited as to local acceptability. These comments were then considered as solutions to problems previously discussed and were developed.

Due to the multitude of political agencies (5) in the basin, and the various stages of implementation of their drainage plans, total sub-basin cooperation could be difficult to obtain.

Staff members from the King County Public Works Department, Division of Hydraulics; Snohomish County, Engineering and Planning Departments; City of Edmond, Public Works Department; City of Lynnwood, Public Works Department and the City of Mountlake Terrace, Public Works Department; have jointly reviewed the initial alternative plans for drainage developed by this RIBCO Study for the McAleer Creek Sub-Basin.

ALTERNATIVE PLANS FOR PROPOSED DRAINAGE CONTROL

The existing drainage system of the McAleer Creek Sub-Basin, as described by local agencies, was evaluated by computer simulation as

applied to the region's 10-year storm to the year 2000 land use. Drainage problems thus identified were analyzed and possible solutions were provided for development of alternative drainage control plans as described below.

Two major alternative plans for solving the McAleer Creek drainage problem were studied. The first alternative, which is itemized for both the 2000 Comprehensive Land Use Plan and the 2000 Corridor Land Use Plan, proposed enlargement of conduits and channel and stream bank protection, and the second being a combination of the above with runoff control features. The description of these alternatives follows.

ALTERNATIVE PLAN I
(Comprehensive and Corridor Land Use)

General Concept

The basic approach for Alternative Plan I is continuation of present trends to provide adequate storm drainage facilities to discharge runoff to the nearest natural receiving water as quickly as possible. The plan consists of conveyance-system enlargement where required and streambank protection that would maintain stable channels under increased flows.

Major Features

The Hall Creek channel, downstream of 220th Street S.W. through Ballinger School, will require increased capacity. Various culverts and storm-drain systems also will require increased capacity in order to pass peak runoff rates to Hall Creek. The eminent channel through the Mountlake Terrace Golf Course will require streambank protection in order to prevent erosion. Some channel modification for local problems might also be required.

The outlets of both Echo Lake and Lake Ballinger, as well as the culverts beneath I-5 at the 205th Street interchange, will require enlargement. The channel below I-5 will have adequate capacity to accommodate projected flow, but will require extensive streambank protection to maintain existing banks increased flows. Two culverts will require enlargement the most significant being the culvert under Bothell Way. Because the downstream reach through a heavily urbanized residential area also would require enlargement, a portion of the stream should be diverted directly to Lake Washington.

Operation and maintenance of the open channel system will consist of maintaining the channel at its proposed size to provide adequate capacity, and to repair any erosion damage to the streambanks. Culverts and bridges will require periodic cleaning of any accumulated debris and sediment. Operation and maintenance will require much greater effort than is currently being expended.

Cost

The estimated cost for the Comprehensive Alternative Plan I is $3,200,000. The estimated cost for the Corridor Alternative Plan I is $3,200,000.

ALTERNATIVE PLAN II

General Concept

This alternative plan, on-site runoff control, would be required throughout the watershed to control runoff to existing levels. Both Echo Lake and Lake Ballinger would need to be controlled to provide adequate storage so as to reduce downstream flows to manageable levels.

Major Features

On-site runoff detention will be provided throughout the watershed to control runoff to rates that presently occur. Because the subbasin is presently heavily urbanized, the 25% limit for runoff increase in peak flow rates, as presently specified by King County, would overtax the drainage system and any significant relief to the problem would not be provided. As runoff control will be provided, the Corridor and Comprehensive land-use plans will indicate the same runoff.

Lake Ballinger and Echo Lake will require structures to control the lake levels and outflows so that releases will not overload downstream channels and the I-5 Freeway culvert. The estimated storage capacity for the control of the 100-year/4-hour storm event is approximately 100 acre feet. This would mean about a one foot rise in the lake's level. Minor storage might be required at the freeway culvert, therefore, it will be flood-plain zoned.

McAleer Creek would experience erodable velocities but of much less severity than those of the previous alternative. Diversion of flow at Bothell Way will be required, but with smaller magnitude than for Alternative Plan I.

Operation and maintenance requirements for this alternative plan would be shifted from channel repair and clean up of Alternative Plan I to lake-level control at Lake Ballinger and Echo Lake. Management of the lake's level is a sufficiently critical need that either automatic controls or constant supervision should be provided. Automatic controls are estimated to be less costly once the system has been planned and programmed.

Cost

The estimated cost for this alternative is $1,700,000.

PEAK FLOW COMPARISONS

The following table indicates 10-year peak flows under existing facilities and land use and with alternative drainage management solutions for the year 2000.

COMPARISON OF 10-YEAR PEAK FLOWS
(Cubic Feet Per Second)

	Comprehensive Land Use	Comprehensive Land Use	Corridor Land Use	Comprehensive & Corridor Land Use
Location	Existing* Facilities	Alternative Plan I	Alternative Plan I	Alternative Plan II
Hall Creek 66th Ave. W	245	390	355	300
Hall Creek 220th St. S.W.	445	590	460	460
Lake Ballinger Outlet	380	825	770	75
Echo Lake Outlet	11	115	110	11
I-5 Freeway Culvert	45	850	780	115
Lake Washington	280	975	975	440

*Note flows constricted by upstream flooding.

ENVIRONMENTAL ASSESSMENT OF ALTERNATIVE PLANS

Field inspections were made to determine applicability of suggested alternatives for this sub-basin. This procedure was followed throughout the RIBCO Study in developing alternative plans on the various regional sub-basins. The inspections were based on the alternative evaluation procedure which identified 34 unique criteria grouped in general categories as follow: 1) Effectiveness, 2) Human Values, 3) Environmental Factors, 4) Implementation, and 5) Resource Requirements. The various structural solutions were checked against the appropriate criteria. The various non-structural solutions were reviewed for their relationship to existing and probable future developments. The criteria rating total for Alternative Plan I, which employs extensive channelization, culvert enlargements, streambank protection and diversion of the lower creek, was a minus 47 for both the Comprehensive and Corridor Plans out of a possible range from a positive total of 108 to a negative

total of 108. The evaluation rating for Alternative Plan II, which employs some structural development, lake storage, runoff control and some flood plain zoning, was a positive 14.

Both alternative plans where judged to be effective for controlling drainage. Both plans involved certain sacrifices of human value and human uses of the plans once they are built. Environmentally, Alternative Plan II clearly offered more resource preservation potential than Alternative Plan I, which required extensive streambank protection and culvert enlargement throughout the entire sub-basin. Implementation of either alternative is made difficult because of the extensive inter-agency coordination required between the six affected agencies. Both of the alternative plans involve commitments of the use and management of natural resources because they rely heavily upon structural treatments for all or part of their solution. However, Alternative Plan II is slightly superior in this regard.

Alternative Plan II relies upon runoff control and some flood-plain zoning for future land development. This treatment combination, if it is to be part of the chosen alternative, should be implemented as an early organized effort. Any portion of the sub-basin that develops without these combined controls will require more structural treatment than Alternative Plan II can accommodate. This issue should be brought to the attention of all citizens and their local agencies.

There also are other sacrifices involved in the two alternative plans. Both plans require rip-rapping of a large section of the creek banks; however, Alternative Plan II offers a possibility of much less streambank protection than Alternative Plan I. Because much of this area is residential in nature, installation of rip-rap has a very negative impact.

CONCLUSIONS

Alternative Plan II is superior to Alternative Plan I in all categories other than implementation, an area where they are equally difficult. As pointed out earlier, runoff control and some flood-plain zoning is required to implement Alternative Plan II.

All involved agencies; King County, Snohomish County, Mountlake Terrace, Edmonds, Lynnwood, and Lake Forest Park, should establish an effective agreement for development of a master drainage plan that incorporates the provisions of Alternative Plan II. All agencies should then move to implement and enforce the required runoff controls and flood-plain zoning within their own jurisdiction.

RUNOFF QUALITY SUMMARY
McALEER CREEK

BASED UPON A 10-YEAR STORM PRECEDED BY 15 DAYS WITH LITTLE OR NO RAINFALL#

LOCATION	ALTERNATIVE PLAN	PEAK FLOW (cfs)	CONCENTRATION AT PEAK FLOW*				
			BOD	TOTAL COLIFORM	NH_3	$NO_2 + NO_3$	PO_4
Mouth	2000 Comprehensive Land Use						
	I	975	19	3.4×10^5	.6	1.5	.5
	II	440	11	2.0×10^5	.2	.9	.3
Mouth	2000 Corridor Land Use						
	I	975	17	5.2×10^5	.6	1.3	.4
	II	440	11	2.0×10^5	.2	.9	.3

Less than a total of 0.5 inches of rainfall in any one day.
* Concentrations in mg/liter except total coliform which is in MPN/100 ml.

EVALUATION MATRIX

MC ALEER CREEK

		EFFECTIVENESS									HUMAN VALUES								ENVIRONMENTAL FACTORS										IMPLEMENTATION							RESOURCE REQUIREMENTS				
ALTER-NATIVES	SUB TOTAL	Use of existing facilities	System reliability	System maintainability	System flexibility	Flood damage reduction	Consequences of overcharge	Erosion and sedimentation control	Cost/benefits ranking	SUB TOTAL	Urban quality (aesthetics)	Effect on land use	Displacement of people	Educational value	Community cohesion	Multiple use potential	Public health and safety	SUB TOTAL	High flow conditions	Alteration of natural system	Effects on groundwater	Low flow conditions	Water quality	Construction disruption	Effects on wildlife	Effects on aquatic life	Effects on vegetation	SUB TOTAL	Legislative requirements	Jurisdictional	Land acquisition	Public acceptance	Financing	Effects of no action	SUB TOTAL	Energy	Materials	Land	Capital	RATING TOTAL
		CRITERIA WEIGHT									CRITERIA WEIGHT								CRITERIA WEIGHT										CRITERIA WEIGHT							CRITERIA WEIGHT				
		1	4	3	2	4	4	4	2		4	2	2	1	3	3	4		4	4	4	4	4	2	4	4	4		4	4	2	4	4	3		3	3	2	2	
I Corr.	+2									-9								-18										-12							-10					-47
I Comp.	+2									-9								-18										-12							-10					-47
II	+16									+2								+14										-12							-6					+14

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative I   Sub Basin McAleer Creek Comprehensive Plan

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
74	Culvert	24"	100'			Parallel Culvert	3' x 10'	$37,000
56	Pipe	36"	550'			Parallel Pipe	42"	$50,000
41	Culvert	3.5'	100'	0	2.5'	Parallel Culvert	21"	$7,000
39	Pipe	24"	2,700'			Parallel Pipe	27"	$127,000
38	Pipe	36"	1,100			Parallel Pipe	21"	$40,000
36	Pipe	24"	650'			Parallel Pipe	18"	$20,000
33	Channel	8'	2,200'	3:1	4'	Channel	36' width 4' depth 1:1 side slopes	$83,000
76	Culvert	5'	100'	0	3'	Replacement Culvert	20' x 4'	$71,000
54	Pipe	30"	300'			Parallel Pipe	27"	$18,000
72	Pipe	30"	300'			Parallel Pipe	27"	$16,000
30	Culvert	24"	100'			Parallel Culvert	48"	$18,000
28	Pipe	30	2300'			Parallel Pipe	48"	$214,000
26	Channel	16'	420'	2:1	4.5'	Channel	25' width 6' depth 1:1 side slopes	$8,000
45	Weir	10'	3'	0	6'	Weir	Remove	- 0 -
24	Culvert	5'	56'			Replacement Culvert	15' x 7'	$33,000
23	Channel	20'	290'	2:1	4'	Channel	2.5' width 6' depth 1:1 side slopes	$5,000
22	Culvert	60"	22'			Parallel Culvert	15' x 7'	$13,000

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative I   Sub-Basin McAleer Creek Comprehensive Plan

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
20	Culvert	60"	440'			Replacement Culvert	12' x 7'	$226,000
49	Culvert	24"	100'			Parallel Culvert	48"	$18,000
16	Culvert	72"	700'			Replacement Culvert	10' x 7'	$325,000
14	Pipe	24"	800'			Parallel Pipe	21"	$29,000
5	Culvert	72"	80'			Replacement Culvert	6' x 6'	$27,000
2	Culvert	25'	200'	•0	6'	Replacement Culvert	35' x 5'	$256,000
1	Channel and 3 Bridges	12'	1,100'	0	3'	Diversion Culvert	9' width 6' depth Vertical sides	$470,000
42	Channel	10'	300'	2:1	5'	Channel	Streambank protection	$45,000
32	Channel	12'	1,600'	1:1	5'	Channel	Streambank protection	$57,000
18	Channel	6'	2,500'	5:1	5'	Channel	Streambank protection	$128,000
63	Channel	4'	1,000'	2:1	10'	Channel	Streambank protection	$45,000
13	Channel	12'	700'	2.5:1	6'	Channel	Streambank protection	$28,000
12	Channel	12'	1,800'	3:1	6'	Channel	Streambank protection	$114,000
8	Channel	12'	3,800'	2.5:1	10'	Channel	Streambank protection	$206,000
6	Channel	4'	4,400'	2:1	10'	Channel	Streambank protection	$197,000
47	Channel	6'	5,500'	2:1	6'	Channel	Streambank protection	$185,000
3	Channel	12'	2,300'	3:1	6'	Channel	Streambank protection	$109,000

The Estimated Capital Cost for each element includes Contractor profit, engineering, legal and contingencies. In addition, land purchase and severance costs are included where land is required. All costs are based upon June 1973 prices.

Total Estimated Capital Cost: $3,225,000
Round To: $3,200,000

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative I Sub Basin McAleer Creek Corridor Plan

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
74	Culvert	24"	100'			Parallel Culvert	10' x 3'	$37,000
56	Pipe	36"	550'			Parallel Pipe	42"	$50,000
41	Culvert	3.5'	100'	0	2.5'	Parallel Culvert	21"	$7,000
39	Pipe	24"	2,700'			Parallel Pipe	21"	$97,000
36	Pipe	24"	650'			Parallel Pipe	18"	$20,000
33	Channel	8'	2,200'	3:1	4'	Channel	30' width 4' depth 1:1 side slopes	$49,000
76	Culvert	100'	100'	0	3'	Replace-ment culvert	15' x 4'	$51,000
54	Pipe	30"	300'			Parallel Pipe	27"	$18,000
72	Pipe	30"	300'			Parallel Pipe	36"	$23,000
30	Culvert	24"	100'			Parallel Culvert	48"	$18,000
28	Pipe	30"	2,300'			Parallel Pipe	60"	$276,000
26	Channel	16'	422'	2:1	4.5'	Channel	25' width 6' depth 1:1 side slopes	$8,000
45	Weir	10'	3'	0	6'		Remove	0
24	Culvert	48"	56'			Replace-ment Culvert	18' x 6'	$36,000
23	Channel	20'	290'	2:1	4'	Channel	25'	$5,000
22	Culvert	60"	22'			Parallel Culvert	18' x 6'	$14,000
20	Culvert	60"	440'			Replace-ment Culvert	12' x 7'	$226,000

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative I Sub Basin McAleer Creek Corridor Plan

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
49	Culvert	24"	100'			Parallel Culvert	48"	$18,000
16	Culvert	72"	700'			Replacement Culvert	10' x 7'	$325,000
14	Pipe	24"	800'			Parallel Pipe	24"	$34,000
5	Culvert	6'	80'			Replacement Culvert	6' x 6'	$27,000
2	Culvert	15'	200'	0	6'	Replacement Culvert	35' x 5'	$256,000
1	Channel and 3 Bridges	12'	1,100'	0	3'	Diversion Culvert	9' width, 6' depth Vertical sides	$470,000
42	Channel	10'	800'	2:1	5'	Channel	Streambank protection	$45,000
32	Channel	12'	1,600'	1:1	5'	Channel	Streambank protection	$57,000
18	Channel	6'	2,500'	5:1	5'	Channel	Streambank protection	$128,000
63	Channel	4'	1,000'	2:1	10'	Channel	Streambank protection	$45,000
13	Channel	12'	700'	2.5:1	6'	Channel	Streambank protection	$28,000
12	Channel	12'	1,800'	3:1	6'	Channel	Streambank protection	$114,000
8	Channel	12'	3,800'	2.5:1	10'	Channel	Streambank protection	$205,000
6	Channel	4'	4,400'	2:1	10'	Channel	Streambank protection	$197,000
47	Channel	6'	5,500'	2:1	6'	Channel	Streambank protection	$185,000
3	Channel	12'	2,300'	3:1	6'	Channel	Streambank protection	$100,000

The Estimated Capital Cost for each element includes Contractor profit, engineering, legal and contingencies. In addition, land purchase and severance costs are included where land is required. All costs are based upon June 1973 prices.

Total Estimated Capital Cost: $3,179,000

Round To: $3,200,000

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative II Sub-Basin McAleer Creek Comprehensive and Corridor Plan

ELEMENT NUMBER	EXISTING FACILITIES: TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	PROPOSED FACILITIES: TYPE		ESTIMATED CAPITAL COST
41	Culvert	3.5'	100'	0	2.5'	Parallel Culvert	21"	$7,000
74	Culvert	24"	100'			Replacement Culvert	48"	$17,000
56	Pipe	36"	550'			Parallel Pipe	30"	$34,000
33	Channel	8'	2,200'	3.1	4'	Channel	25' width 4' depth 1:1 side slopes	$17,000
76	Culvert	5'	100'	0	3'	Replacement Culvert	13' x 4'	$46,000
54	Pipe	30"	300'			Parallel Pipe	30"	$21,000
72	Pipe	30"	300'			Replacement Pipe	54"	$36,000
31	None						Echo Lake Outlet Control	$12,000
28	Pipe	30"	2,300'			Parallel Pipe	36"	$152,000
27	None						Lake Ballinger control	$30,000
21	Channel	18'	700'	2:1	10'	Channel	Flood plain zone	-0-
40	Culvert	24"	100'			Parallel Culvert	48"	$18,000
14	Pipe	24" rough	800'			Parallel Pipe	24" smooth	$34,000
2	Culvert	15'	200'	0	6'	Parallel Pipe	66"	$38,000
1	Channel and 3 Bridges	12'	1,100'	0	3'	Diversion Pipe	66"	$149,000
42	Channel	10'	800'	2:1	5'	Channel	Streambank protection	$45,000
32	Channel	12'	1,600'	1:1	5'	Channel	Streambank protection	$57,000

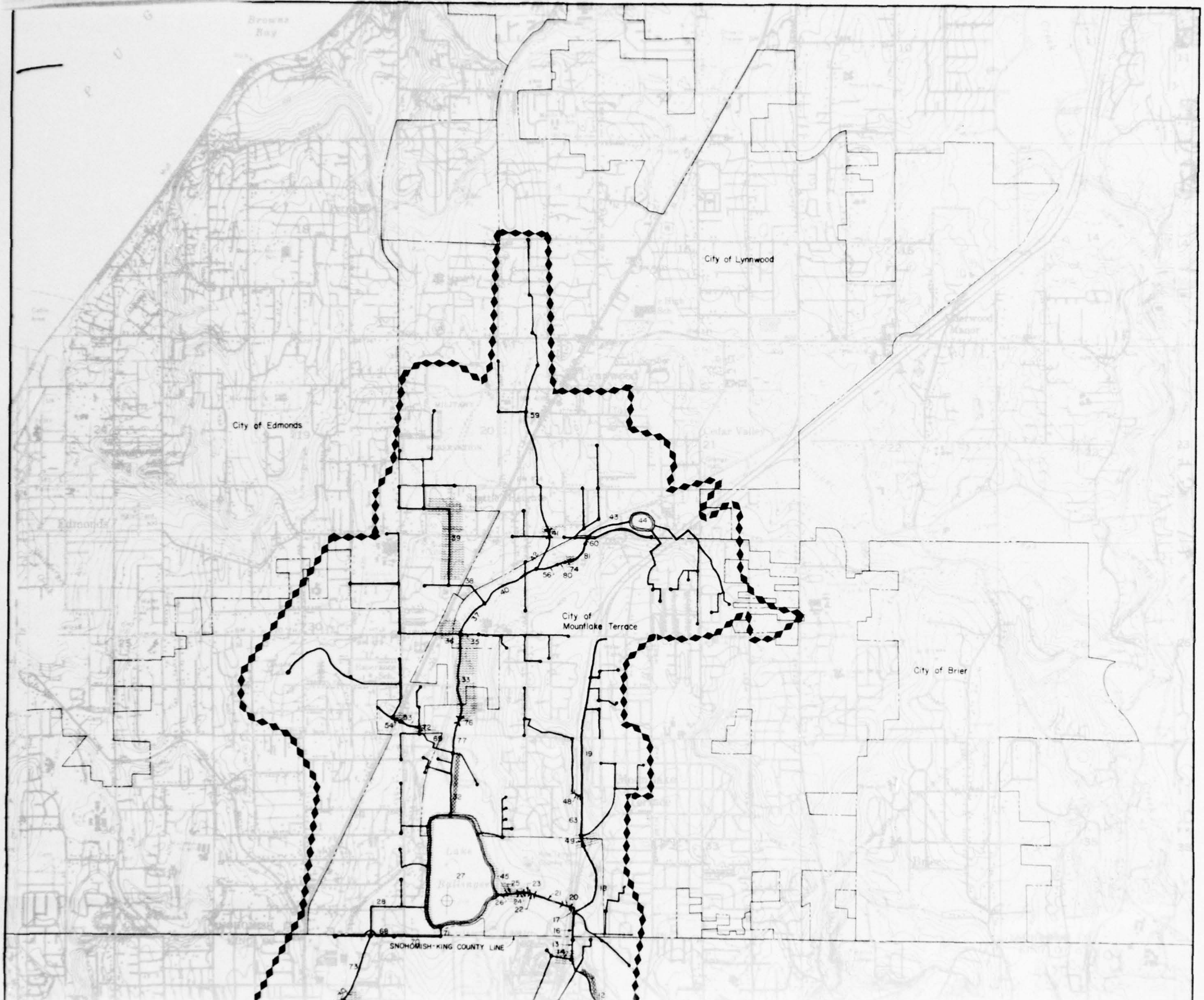
RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative II   Sub-Basin McAleer Creek Comprehensive and Corridor Plan

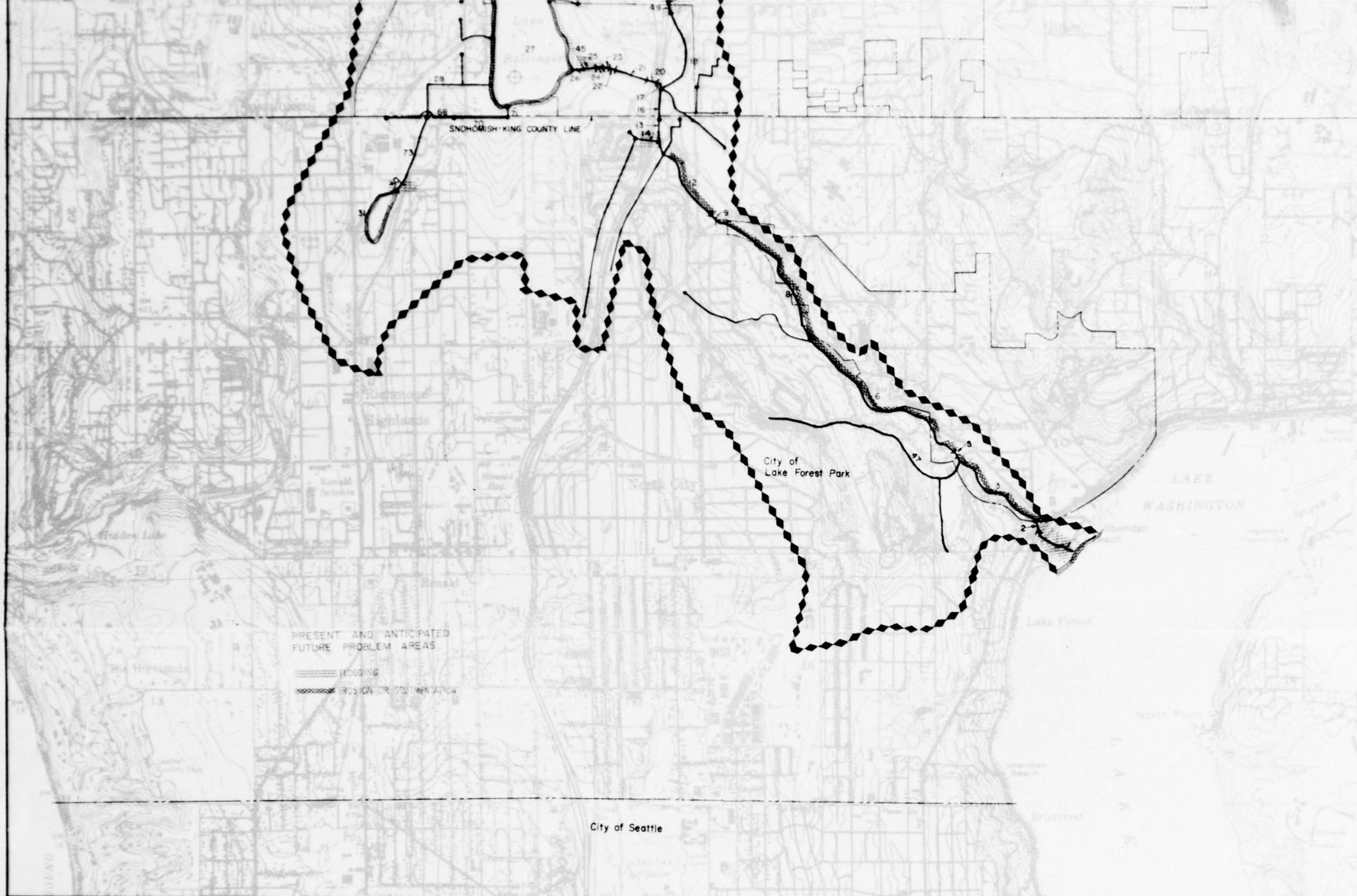
ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
18	Channel	6'	2,500'	5:1	5'	Channel	Streambank protection	$128,000
63	Channel	4'	1,000'	2:1	10'	Channel	Streambank protection	$45,000
13	Channel	12'	700'	2.5:1	6'	Channel	Streambank protection	$28,000
12	Channel	12'	1,800'	3.1	6'	Channel	Streambank protection	$114,000
8	Channel	12'	3,800'	2.5:1	10'	Channel	Streambank protection	$206,000
6	Channel	4'	4,400'	2.1	10'	Channel	Streambank protection	$197,000
47	Channel	6'	5,500'	2:1	6'	Channel	Streambank protection	$185,000
3	Channel	12'	2,300'	3:1	6'	Channel	Streambank protection	$109,000

The Estimated Capital Cost for each element includes Contractor profit, engineering, legal and contingencies. In addition, land purchase and severance costs are included where land is required. All costs are based upon June 1973 prices.

Total Estimated Capital Cost: $1,725,000
Round To: $1,700,000



City of Lynnwood
City of Edmonds
City of Mountlake Terrace
City of Brier
SNOHOMISH-KING COUNTY LINE
Browns Bay
Cedar Valley
Lynnwood
Edmonds



LEGEND

SUB-BASIN BOUNDARY
EXISTING CHANNEL
EXISTING CONDUIT
MANHOLE, INLET, OR JUNCTION
CHANNEL OR CONDUIT DESIG.
CITY LIMITS
COUNTY (METRO) BOUNDARY
LEVEE
CULVERT
HOLDING POND OR LAKE

NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

McALEER CREEK

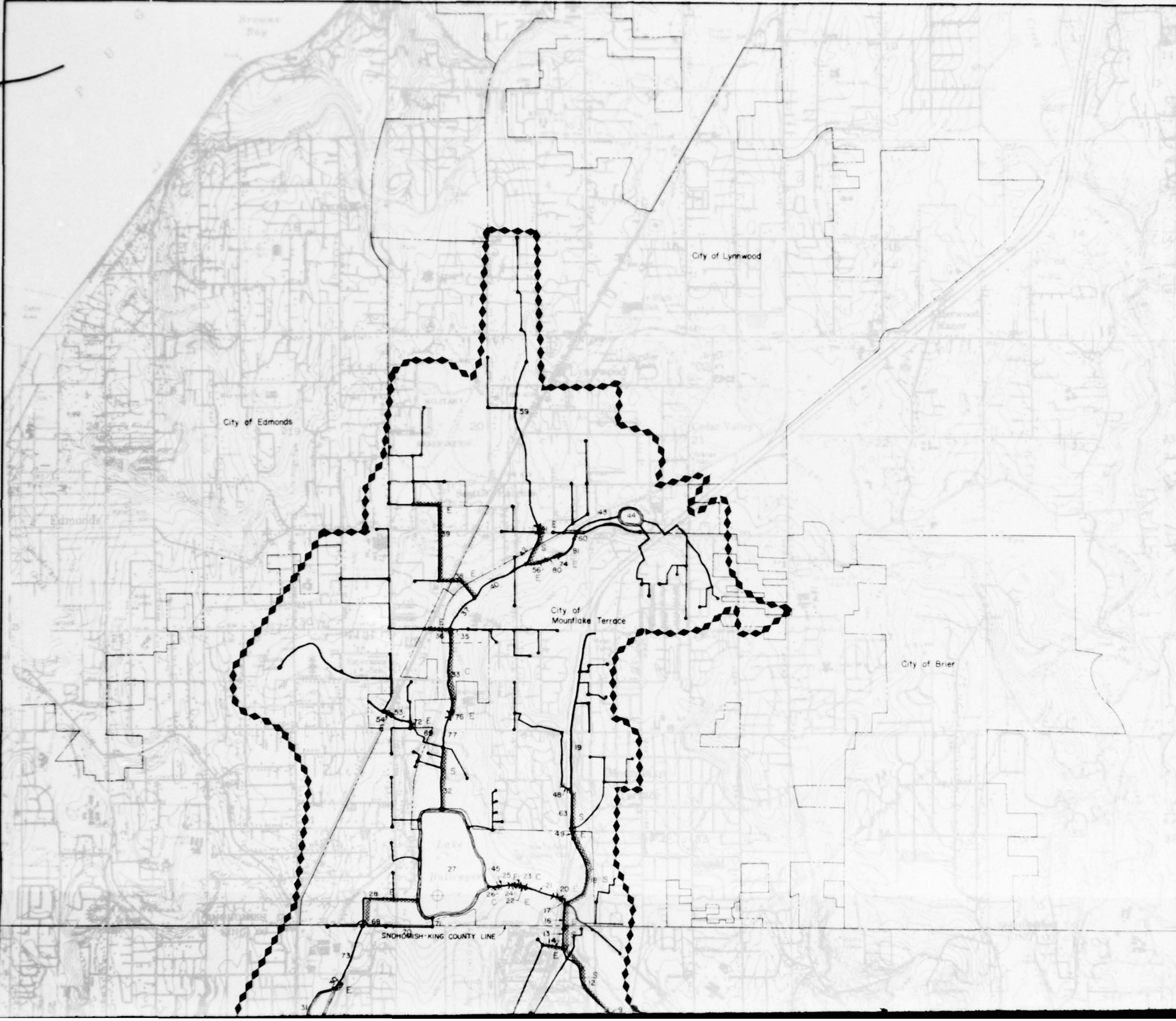
PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

KRAMER, CHIN AND MAYO, INC.
WATER RESOURCES ENGINEERS, INC.
YODER, TROTTER, ORLOB & ASSOCIATES

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO E-26-1-161 SHEET 1? OF 1

2


City of Lynnwood
City of Edmonds
City of Mountlake Terrace
City of Brier
SNOHOMISH-KING COUNTY LINE

LEGEND

SUB-BASIN BOUNDARY
EXISTING CHANNEL
EXISTING CONDUIT
MANHOLE, INLET, OR JUNCTION
CHANNEL OR CONDUIT DESIG 5
CITY LIMITS
COUNTY (METRO) BOUNDARY
LEVEE

CULVERT
HOLDING POND OR LAKE

N

MILES 1/2 1/4 0 1

FEET 1000 500 0 4000

NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

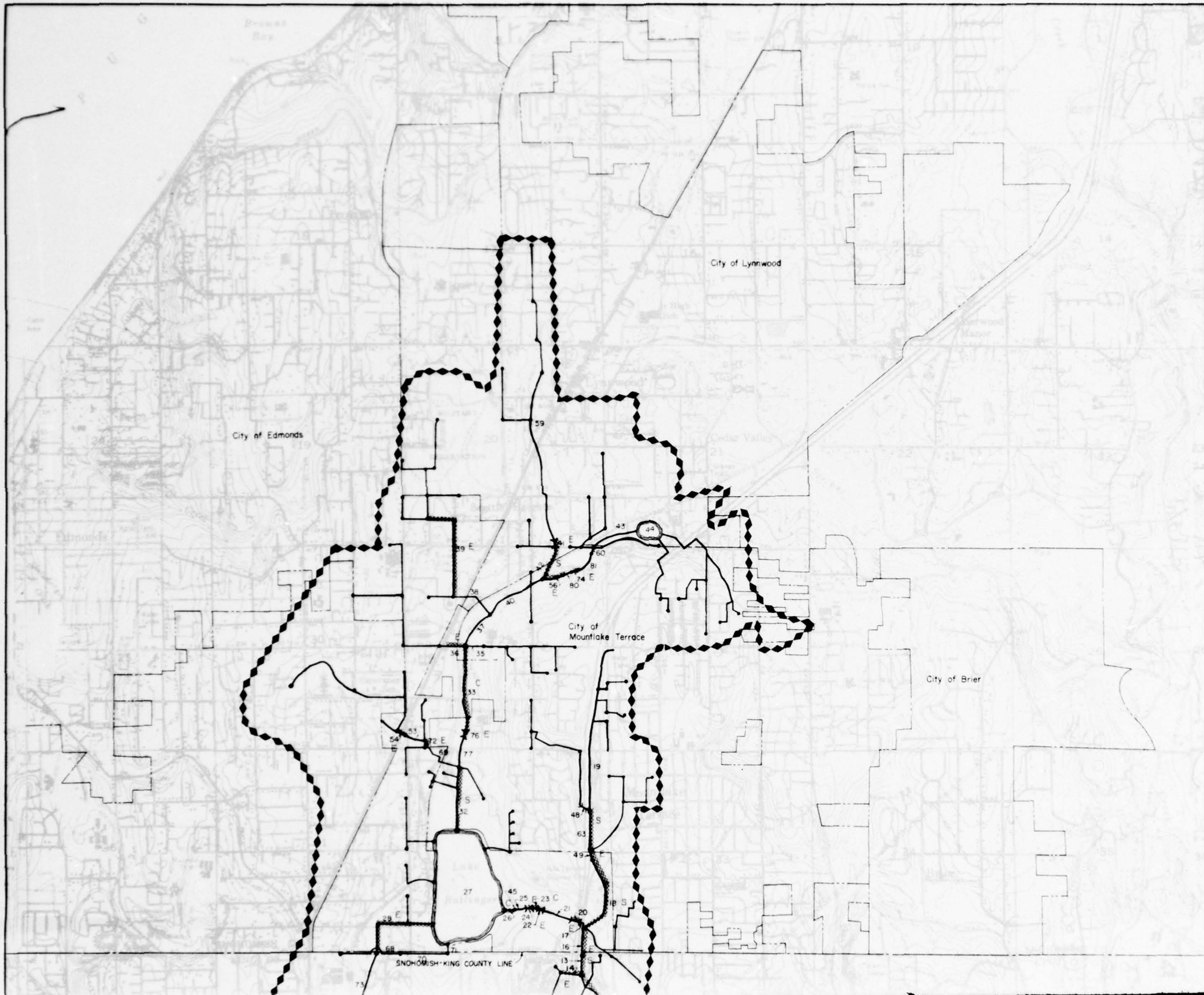
McALEER CREEK

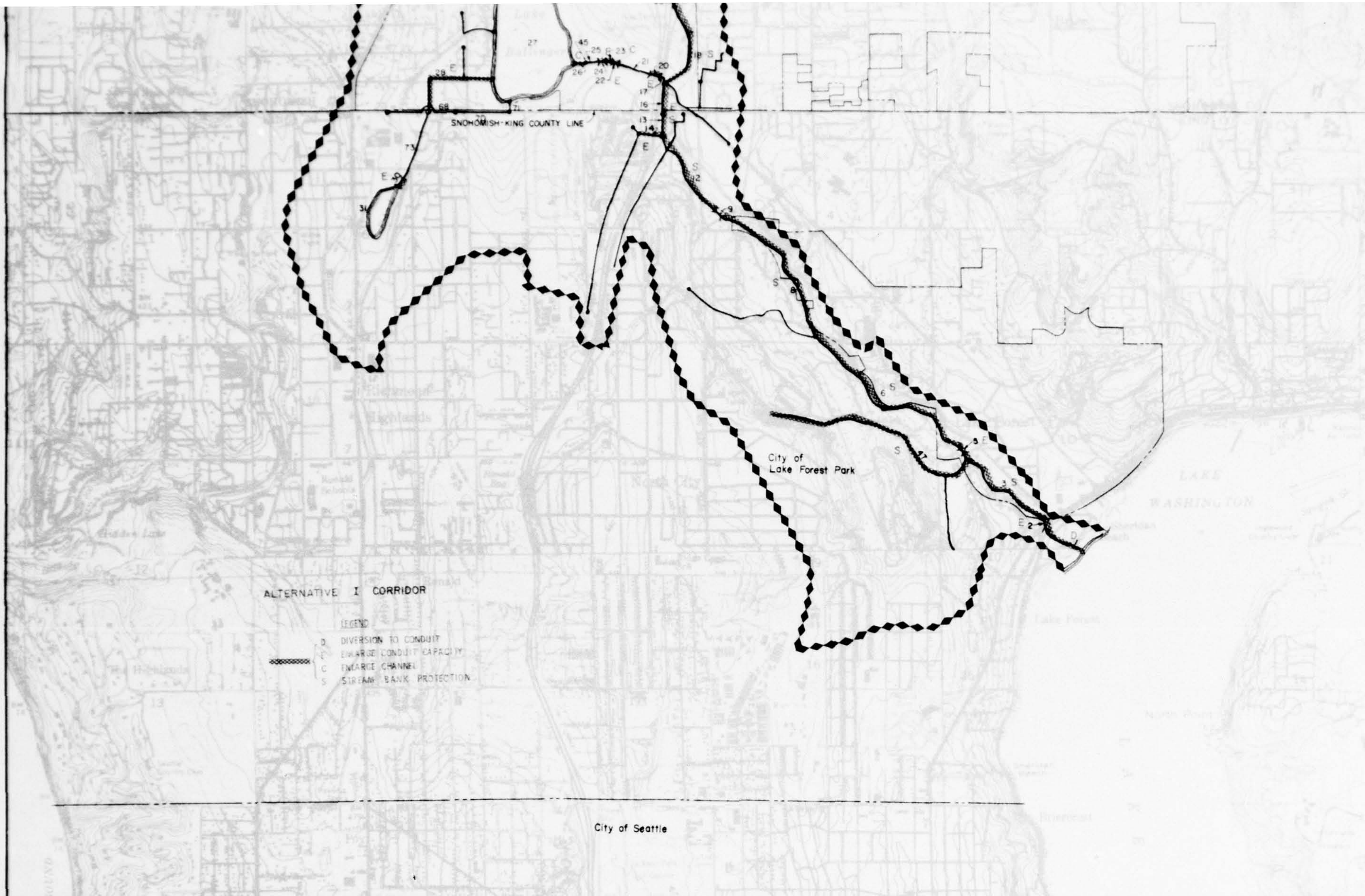
PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

KRAMER, CHIN AND MAYO, INC
WATER RESOURCES ENGINEERS, INC
YODER, TROTTER, ORLOB & ASSOCIATES

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO E-26-1-161 SHEET 1b OF 1


City of Lynnwood
City of Edmonds
City of Mountlake Terrace
City of Brier
SNOHOMISH-KING COUNTY LINE



LEGEND

SUB-BASIN BOUNDARY
EXISTING CHANNEL
EXISTING CONDUIT
MANHOLE, INLET, OR JUNCTION
CHANNEL OR CONDUIT DESIG
CITY LIMITS
COUNTY (METRO) BOUNDARY
LEVEE
CULVERT
HOLDING POND OR LAKE

MILES

FEET

NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

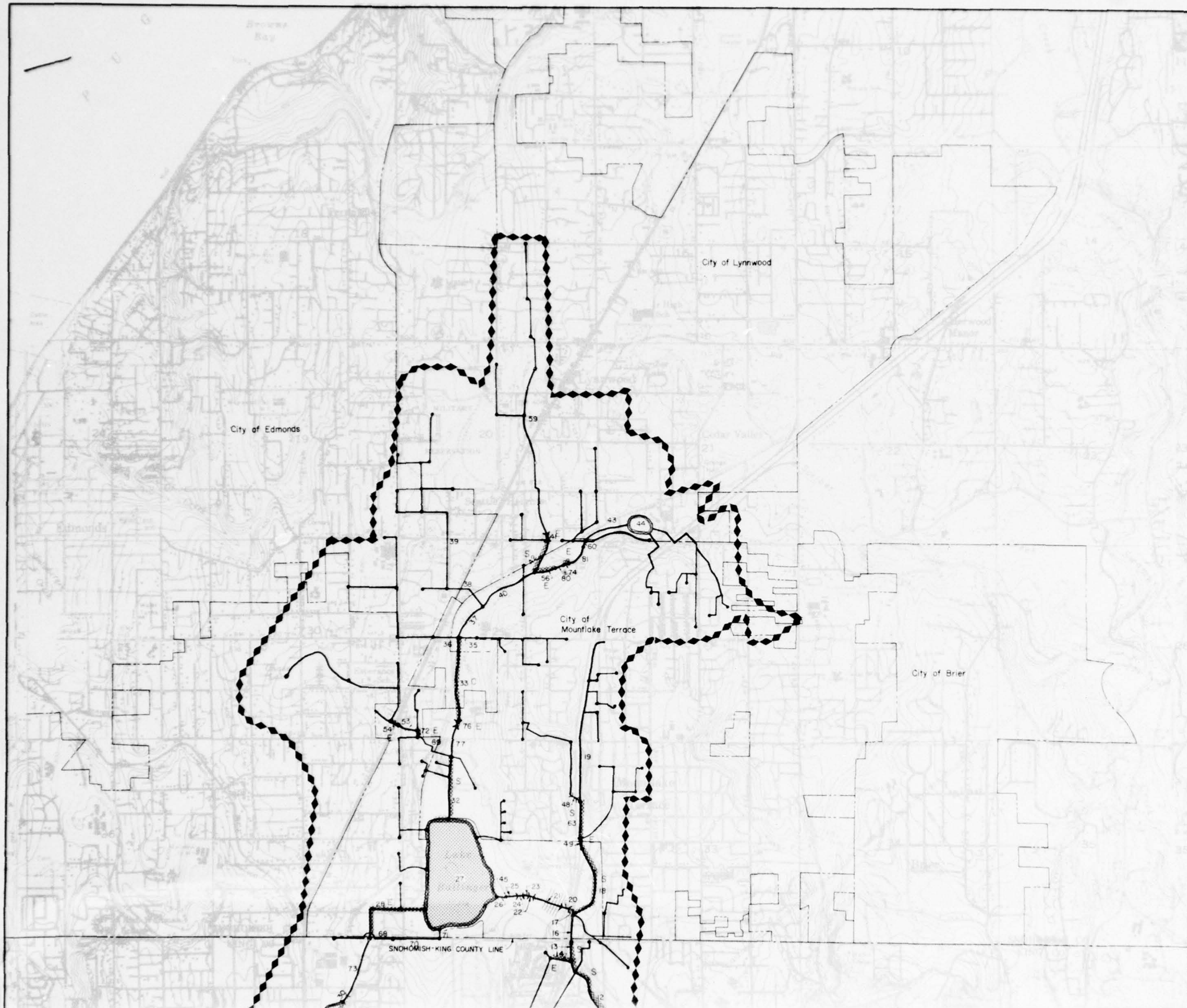
McALEER CREEK

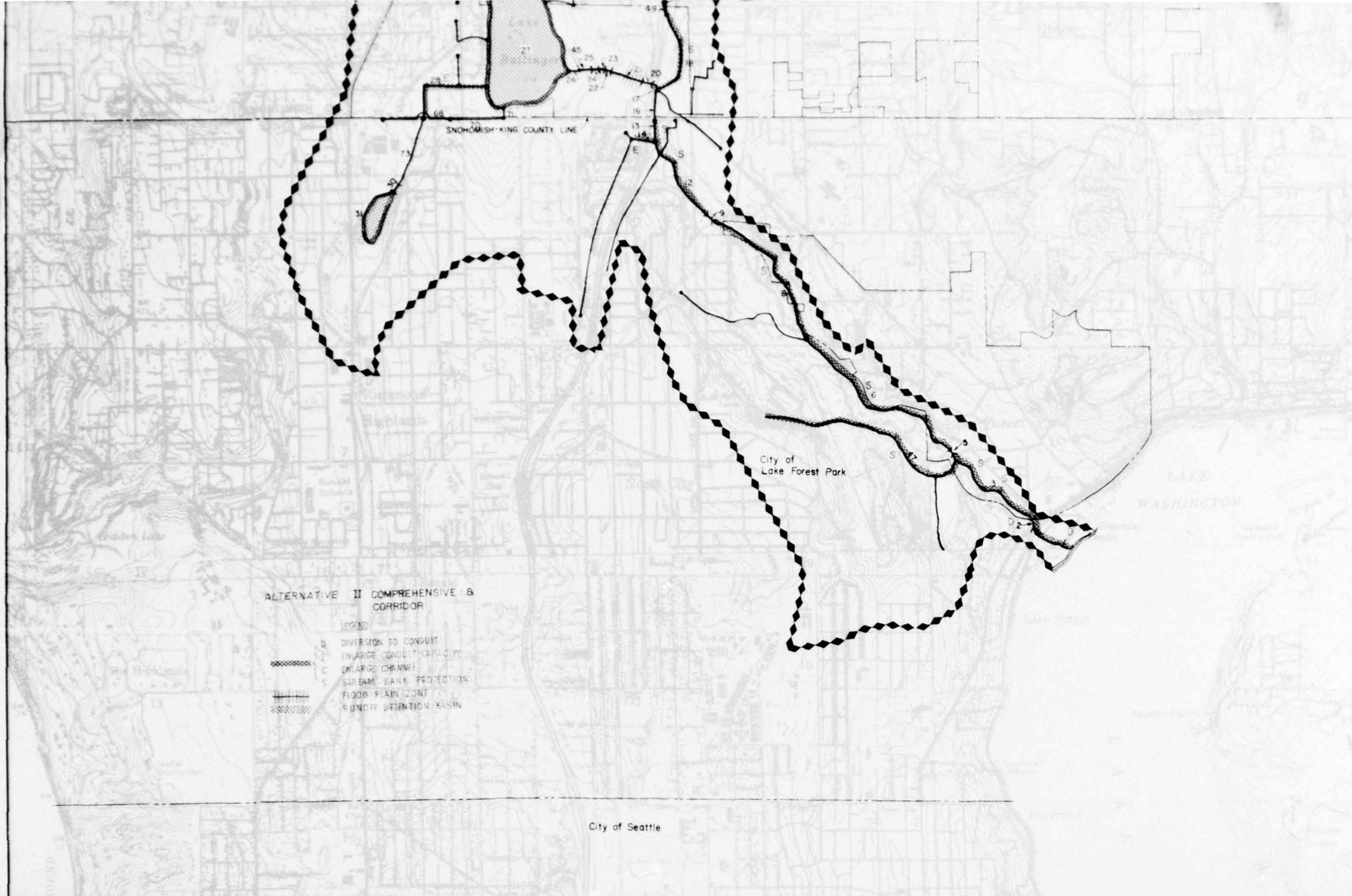
PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

KRAMER, CHIN AND MAYO, INC
WATER RESOURCES ENGINEERS, INC
YODER, TROTTER, ORLOB & ASSOCIATES

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO E-26-1-161 SHEET 1 OF 1


City of Edmonds
City of Lynnwood
City of Mountlake Terrace
City of Brier
SNOHOMISH-KING COUNTY LINE



LEGEND

SUB-BASIN BOUNDARY
EXISTING CHANNEL
EXISTING CONDUIT
MANHOLE, INLET, OR JUNCTION
CHANNEL OR CONDUIT DESIG
CITY LIMITS
COUNTY (METRO) BOUNDARY
LEVEE

CULVERT
HOLDING POND OR LAKE

N

MILES 1/2 1/4 0 1

FEET 1000 500 0 4000

NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

McALEER CREEK

PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

KRAMER, CHIN AND MAYO, INC.
WATER RESOURCES ENGINEERS, INC.
YODER, TROTTER, ORLOB & ASSOCIATES

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO E-26-1-161 SHEET 8 OF 1

REGIONAL SUB-BASIN C-13

THORNTON CREEK

GENERAL DESCRIPTION

The Thornton Creek Sub-Basin is located west of Lake Washington in North Seattle. It lies in a northwest/southeast orientation with the creek draining southeast into Lake Washington at Matthews Beach north of Sand Point. Geography of the sub-basin is generally moderate in the upland area, with several sections of gullies and hills. Total elevation change is from almost 500 ft. to 15 ft. above sea level at Lake Washington. The stream channel is contained in a restricted valley but a narrow flood plain exists throughout most of its length. The City of Seattle controls approximately 70% of the sub-basin with the remainder being in King County.

The principal stream is Thornton Creek that consists of a North Fork and South (West) Fork. The North Fork, which extends for five and a half miles, first appears from a culvert north of Jackson Park Golf Course below Ronald Bog and the South Fork begins in the vicinity of 5th Avenue Northeast near the Northgate Shopping Mall and North Seattle Community College. The North Fork has been designated as a demonstration area and as such has received a separate analysis in this appendix. The forks join at Meadowbrook Park on 35th Ave. N.E. The stream flows through developed residential areas and parklands and changes character numerous times as it is affected by abutting properties. Remnants of wetland areas can be seen above the North Fork at Ronald Bog and an unnamed area near N.E. 155th. Other small wetland areas exist throughout the sub-basin.

Stream	Category	Drainage Area	Discharge
South Fork Thornton Creek	III	5.1 sq. mi.	Lake Washington (Matthews Beach)

Present development in the entire sub-basin consists of extensive residential areas, major commercial centers and a highly developed transportation system that include portions of Interstate 5, Aurora Ave. (State 99), and Lake City Way plus other major local arterials. There are several major parks and institutional uses. The overall character of the sub-basin is urban, with only 2% of the land now undeveloped.

PERCENT OF SUB-BASIN AREA IN SPECIFIED LAND USE

Land Use	Existing (1970-72)	P.S.G.C. Land Use Projection Comprehensive	Corridor
Single Family	76	74	77
Multiple Family		5	2
Commercial/Services	10	10	10
Govt. and Educ.	5	5	5
Industrial			
Parks/Dedicated Open Space	5	4	4
Agriculture			
Airports, Railyards, Freeways, Highways	2	2	2
Unused Land	2		
Water			
Total	100	100	100
Total Impervious Area	45	45	45

The development pattern of this sub-basin is fixed and it allows little latitude for addition or change as is seen in the P.S.G.C. land-use projections. The additions that will occur will be primarily in the commercial and multiple-family residential sector.

NATURE OF EXISTING DRAINAGE SYSTEM

The existing drainage system consists of the two main forks of Thornton Creek, several tributaries, many small gullies, and a partial system of storm drains, curbs, gutters, and culverts along the major arterials. Much of the sub-basin is drained by open channels along the streets. A portion of the South Fork has been channelized and most of the streams have been modified to some extent. Much of the sub-basin, although developed, does not have a storm-drain system and relies upon overland flows to streets and streamways. Street improvements in the sub-basin have been delayed due to lack of drainage facilities.

In a highly urbanized setting such as Seattle, those portions of the streamways that are accessible to the public are great amenities.

By the nature of existing development, it is unlikely that there will be an opportunity to create a continuous greenway and the stream will remain an amenity primarily to those with abutting property and in those stretches of existing public ownership.

The State Department of Game and Department of Fisheries believe that the stream is impassable to fish due to culverts in the lower reaches and therefore consider it an unproductive stream. Local residents, however, have reported spawning by anadromous fish, and there are local varieties of fish in the stream as well.

DRAINAGE PROBLEMS

The Thornton Creek drainage system has been analyzed in two parts. The South Fork, also known as Victory Creek, is discussed herein; the North Fork has been analyzed as a demonstration area.

Problems in the South Fork sub-basin include local ponding in the flat upland areas, erosion in sections of the creek, and sedimentation downstream from the point where it joins with the North Fork near the abandoned Lake City Sewage Treatment Plant.

A temporary problem that adversely affects both water quality and quantity in this sub-basin involves construction now underway in the Northgate area. The construction site is not only the source of considerable sediment, but it also replaces Square Lake which served as a natural detention pond for water upstream.

This sub-basin comprises the main channel of Thornton Creek to Lake Washington, including a 72 inch diameter bypass line originating at the Lake City Sewage Treatment Plant Site and discharging directly to Lake Washington. It is partly due to the capacity of this bypass, and channel restrictions upstream, that erosion problems and flooding in the main channel downstream are not more serious than they have been.

Both the year 2000 Comprehensive and Corridor Land Use Plans indicate a general urbanization of the Thornton Creek Sub-Basin. The results of hydrologic analysis indicate no significant difference between the Comprehensive and Corridor Land-Use Plans. Therefore, the drainage alternatives presented herein are applicable to both plans. The total impervious area in this sub-basin under either land use projection is shown to be at a level approximately equal to the existing 45% coverage.

BASIC ISSUES AND STATUS OF DRAINAGE PLANNING

Existing planning in this sub-basis includes a conventional storm-drain trunk system for the entire Thornton Creek Sub-Basin designed by the City of Seattle. This plan would solve the major drainage problems in this sub-basin, but it would involve a large capital outlay and has not been funded. The City of Seattle Department

of Parks and Recreation has purchased a significant portion of the undeveloped streamside and wetland properties along the South Fork and also operate several parks along the stream.

Important in the planning efforts within this sub-basin is the Thornton Creek Basin Improvement Association (TBIA) that has encouraged the concept of surface water management for the sub-basin. Public meetings held both by TBIA and RIBCO during the course of this planning effort were used as the forum for receiving public comment on local problems.

Staff members from the City of Seattle Engineering Department and Planning Department and representatives from the Thornton Creek Basin Improvement Association have reviewed the initial alternative plans for drainage developed by this RIBCO Study for Thornton Creek Sub-Basin.

ALTERNATIVE PLANS FOR PROPOSED DRAINAGE CONTROL

The existing South Fork drainage system as described by local agencies was evaluated by computer simulation applying the region's 10-year storm to the year 2000 land use. Drainage problems thus identified were analyzed and possible solutions provided in development of alternative plans for drainage control as described below.

ALTERNATIVE PLAN I

General Concept

Although the major emphasis in this alternative is to open up the existing channels to allow passage of all runoff, the elements of detention storage and flow diversion are also included to a limited extent. This plan includes culvert replacement and construction of parallel conduits where present lines are inadequate to accommodate flows, and in areas where erosion is a problem, streambank protection would be provided.

Major Features

The primary effort in this program is enlargement of channel sections to increase their natural capacity. Downstream from the confluence of the North and South Forks, this would involve lining the channels with concrete sidewalls to reduce frictional losses and thereby avoid an unreasonably wide channel that could require the condemnation of some residences. Near the mouth of Thornton Creek between Lake Washington and Sandpoint Way N.E. where the channel is too close to existing homes to allow any significant channel widening, a diversion line would be constructed to carry peak flows directly to the lake. The diversion would allow some flow to continue in its present path so. that the existing stream environment would be maintained. The diversion

line is the single most costly item in this alternative.

As mentioned above, detention storage would be used in this alternative to a limited extent. At North Seattle Community College, there is in existence a storage pond constructed to control flows from the campus. This pond would be enlarged to control runoff not only from the college, but from the entire upstream drainage area.

Cost

The cost for Alternative Plan II is estimated to be $1,700,000.

ALTERNATIVE PLAN II

General Concept

This plan calls for diversion around the South Fork of Thornton Creek to allow all but damaging flows to continue in its present path. This concept also would include a limited amount of detention storage as described in Alternative Plan I, some pipe and culvert replacement, and erosion control at some points along the creek.

Major Features

The most significant element of this plan is the construction of a diversion line beginning on 5th Ave. N.E. and proceeding east to Lake Washington. The line would divert peak flows from the creek and allow a controlled amount to continue in its natural channel for all storms within the design period of 10 years. As the diversion passes the Lake City Treatment Plant, it will pick up the North Fork of Thornton Creek, make full use of the existing bypass line, and continue directly to Lake Washington. Downstream from the Lake City Plant only minor channel protection will be necessary to prevent erosion; all existing channels, bridges, and conduits would be capable of passing expected runoff.

The only other features of this alternative would be enlargement of the North Seattle Community College storage pond, some channel improvements between Lake City Way and Nathan Hale High School, and construction of some parallel storm sewers.

Cost

The cost for Alternative Plan II is estimated to be $3,700,000.

ALTERNATIVE PLAN III

General Concept

The general concept of this plan is basically a compromise between the two previously discussed. It includes additional detention storage, limited channel improvements and culvert replacement, construction of parallel conduits and diversion of peak flows to the Lake City bypass line.

Major Features

The two most costly elements of this alternative are four holding ponds and a diversion line. Detention storage includes enlargement of the North Seattle Community College facility, construction of two new ponds on City property between 5th Ave. N.E. and Roosevelt Way, and the development of a large 20 acre-feet storage facility at the Lake City Sewage Treatment Plant site. An even greater volume could be obtained if either the existing plant structures were removed, or the abandoned tanks and clarifiers were used for storage.

The diversion line would be constructed to parallel the existing bypass line from the plant site down 105th Street to 45th Ave. N.E. where it would enter an existing tunnel that discharges to Lake Washington. The tunnel is part of the Lake City bypass system but is larger than the 72 inch diameter line coming from the plant at the present time and lies at a steeper slope.

The total effect of this plan would be similar to that described in Alternative Plan II except that flows between Roosevelt Way and the Lake City Plant would be higher since no diversion facilities would be provided in between.

Cost

The cost for Alternative Plan III is estimated to be $1,400,000.

PEAK FLOW COMPARISONS

The following table indicates 10-year peak flows under existing facilities and under alternative drainage management solutions for the year 2000. The peak flows are given for various locations along the creek.

COMPARISON OF 10-YEAR PEAK FLOWS
(Cubic Feet Per Second)

South Fork Location	Existing Facilities	Alternative Plan I	Alternative Plan II	Alternative Plan III
105th Ave.N.E./Roosevelt Way	80	270	50	270
35th Ave. N.E.	500	650	280	490
Lake City Treatment Plant	250	1730	380	670
Matthews Beach	150	1780	180	180
Combination of Creek Flow and Diversion Pipeline			1900	

ENVIRONMENTAL ASSESSMENT OF ALTERNATIVE PLANS

Field inspections were made to judge the applicability of the suggested alternative plans for this sub-basin. This procedure was followed throughout the KIBCO Study for development of alternative plans for the various regional sub-basins. The inspections were based upon the alternative evaluation procedure which identified 34 unique criteria grouped in general categories: 1) Effectiveness, 2) Human Values, 3) Environmental Factors, 4) Implementation, and 5) Resource Requirements. The various structural solutions were checked against the appropriate criteria and the various non-structural solutions were reviewed for their relationship to existing and probable future developments. The criteria rating total for Alternative Plan I, which employs channelization, streambank protection and enlarged conduit, was a minus 26 on a scale ranging from a positive 108 to negative 108. The total evaluation rating for Alternative Plan II, which employs storage, a major diversion line, some streambank protection, and some channelization, was a minus 4. The total evaluation rating for Alternative Plan III, which involved storage, enlarged conduit, a smaller diversion system, and some channelization, was a plus 24.

All three alternatives were judged to be marginally effective in controlling drainage because they are felt to be relatively complicated and somewhat difficult to maintain. They all do provide adequate flood damage reduction. In addition, Alternative Plans I and II were believed to be somewhat inflexible and incapable of further change or addition. Alternative Plans II and III received positive rating for promotion of human values while Alternative Plan I was felt to be detrimental to human values. This judgment primarily is based upon the fact that in Alternative Plan I the entire Thornton Creek South Fork must be channelized or provided streambank protection, thereby destroying the natural quality that exists at this time. Alternative Plans II and III also received a positive rating for environmental factors. Both alternatives should improve stream water quality and may actually allow fisheries to be re-established in the stream. Alternative Plan I was downgraded again because of its extensive alteration of the natural system and the disruptive effects on wildlife and vegetation. Alternative Plans I and III received positive rating on their implementation potential but for the future and requires action by only one jurisdiction. While Alternative Plan III requires action by only one jurisdiction, it must be implemented in the fairly immediate future because of its reliance upon storage areas available at this time. Alternative Plan III Concept also has the known public acceptance. All three alternative plans were considered to require extensive resource commitments, both in terms of money and materials. Only Alternative Plan III had land requirements that could be used for more than one purpose.

A critical element in both Plans II and III is the storage within the sub-basin necessary to reduce flows that the natural stream must

carry. Both alternative plans utilize storage at North Seattle Community College and in addition, Alternative Plan III requires designation of storage within areas which have been recently acquired by the City of Seattle, Department of Parks and Recreation. The use of these areas for storage must be accomplished with the cooperation of the Department of Parks and Recreation and prior to commitment to any park development schemes for these sites.

CONCLUSIONS

Alternative Plan III is clearly superior to either Alternative Plan I or II, but it does require fairly immediate action to gain access rights to the holding ponds vital to the functioning of this system. The Thornton Creek Sub-Basin has developed to an extent that runoff controls for new development would have a very minor impact, and therefore all solutions presented do involve construction within the stream that must be handled in a most cautious manner.

The City of Seattle has total jurisdiction over the South Fork of the Thornton Creek Sub-Basin and therefore is in a position to implement whatever master drainage plan it develops. The condition of Thornton Creek is such that without sensitive and immediate action, it eventually will need to be controlled in a manner that would be detrimental to the character of the stream as it now exists.

RUNOFF QUALITY SUMMARY
THORNTON CREEK

BASED UPON A 10-YEAR STORM PRECEDED BY 15 DAYS WITH LITTLE OR NO RAINFALL#

LOCATION	ALTERNATIVE PLAN	PEAK FLOW (cfs)	CONCENTRATION AT PEAK FLOW*				
			BOD	TOTAL COLIFORM	NH_3	$NO_2 + NO_3$	PO_4
Mouth of Creek	I	1780	22	4.9×10^5	.6	1.6	.2
	II	1900	18	3.6×10^5	.4	1.3	.1
	III	180##	10	2.0×10^5	.2	.7	.1

\# Less than a total of 0.5 inches of rainfall in any one day.
* Concentrations in mg/liter except total coliform which is in MPN/100 ml.
** Combined peak flow of diversion and Thornton Creek.
\## Flow at mouth of creek only, diversion flow not shown.

EVALUATION MATRIX

THORNTON CREEK

ALTER- NATIVES	SUB TOTAL	Use of existing facilities	System reliability	System maintainability	System flexibility	Flood damage reduction	Consequences of overcharge	Erosion and sedimentation control	Cost/benefits ranking	SUB TOTAL	Urban quality (aesthetics)	Effect on land use	Displacement of people	Educational value	Community cohesion	Multiple use potential	Public health and safety	SUB TOTAL	High flow conditions	Alteration of natural system	Effects on groundwater	Low flow conditions	Water quality	Construction disruption	Effects on wildlife	Effects on aquatic life	Effects on vegetation	SUB TOTAL	Legislative requirements	Jurisdictional	Land acquisition	Public acceptance	Financing	Effects of no action	SUB TOTAL	Energy	Materials	Land	Capital	RATING TOTAL
		EFFECTIVENESS									HUMAN VALUES								ENVIRONMENTAL FACTORS										IMPLEMENTATION							RESOURCE REQUIREMENTS				
		CRITERIA WEIGHT									CRITERIA WEIGHT								CRITERIA WEIGHT										CRITERIA WEIGHT							CRITERIA WEIGHT				
		1	4	3	2	4	4	4	2		4	2	2	1	3	3	4		4	4	4	4	4	2	4	4	4		4	4	2	4	4	3		3	3	2	2	
I	+1									-4								-14										+1							-10					-26
II	0									+1								+6										-1							-10					-4
III	+4									+4								+12										+4							0					+24

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative I   Sub Basin Thornton Creek

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
36	Pipe	36"	900'			Parallel Pipe	42"	$71,000
115	Pipe	12"	2,400'			Parallel Pipe	12"	$48,000
116	Pipe	15"	600'			Parallel Pipe	36"	$40,000
24	Culvert	Two - 48" CMP	50'			Replacement Culvert	72"	$7,000
20	Culvert	84" CMP	100'			Parallel Culvert	66"	$14,000
6	Culvert	8'	50'	0	4'	Replacement Culvert	12' x 7'	$47,000
4	Culvert	8'	50'	0	6'	Replacement Culvert	12 x 6'	$47,000
1	Channel	12'	1,100'	1:1	6'	Diversion Pipe	Two 108" lines (Element 244)	$513,000
119	Pipe	15"	2,300'			Parallel Pipe	24"	$97,000
33	Channel	4'	1,100'	1:1	2'	Channel	5' width 2.5' depth 2:1 side slopes	$3,000
32	Channel	4'	700'	1:1	2'	Channel	6' width 2.5' depth 2:1 side slopes	$3,000
28	Channel	8'	500'	1:1	2'	Channel	8' width 2.5' depth 2:1 side slopes	$5,000
27	Channel	10'	3,000'	1:1	4'	Channel	Streambank protection	$23,000
25	Channel	5'	1,600'	1:1	3'	Channel	8' width 4' depth 2:1 side slopes	$25,000
23	Channel	10'	700'	1:1	3'	Channel	10' width 4' depth 2:1 side slopes	$12,000
19	Channel	20'	300'	1:1	4'	Channel	26' width 6' depth 2:1 side slopes	$9,000
15	Channel	12'	200'	1:1	4'	Channel	26' width 6' depth 2:1 side slopes	$7,000

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative 1 Sub-Basin Thornton Creek

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
13	Channel	12'	300'	1:1	4'	Channel	12' width 5' depth Concrete lined 2:1 side slopes	$52,000
11	Channel	12'	400'	1:1	3'	Channel	12' width 5' depth Concrete lined 2:1 side slopes	$63,000
9	Channel	10'	2,000'	1:1	4'	Channel	12' width 5' depth Concrete lined 2:1 side slopes	$303,000
7	Channel	10'	500'	1:1	4'	Channel	12' width 5' depth Concrete lined 2:1 side slopes	$69,000
5	Channel	10'	300'	1:1	4'	Channel	30' width 6' depth 2:1 side slopes	$13,000
3	Channel	12'	200'	1:1	4'	Channel	30' width 6' depth 2:1 side slopes	$13,000
16	Channel	12'	300'	1:1	4'	Channel	26' width 6' depth 2:1 side slopes	$11,000
12	Channel	12'	40'	1:1	4.5'	Channel	17' width 6' depth Vertical wall Concrete lined	$18,000
10	Channel	10'	40'	1:1	4'	Channel	17' width 6' depth Vertical wall Concrete lined	$18,000
8	Channel	16'	60'	1:1	6'	Channel	17' width 6' depth Vertical wall Concrete lined	$18,000
232	Holding Pond	2.0 AF				Holding Pond	8.5 AF	$132,000
20	None					Inlet/ Outlet	To 66"	$11,000
6	None					Inlet/ Outlet	For 12' x 7' culvert	$18,000
4	None					Inlet/ Outlet	For 12' x 6' culvert	$18,000
2	None					Inlet/ Outlet	For culvert	$18,000

The Estimated Capital Cost for each element includes Contractor profit, engineering, legal and contingencies. In addition, land purchase and severance costs are included where land is required. All costs are based upon June 1973 prices.

Total Estimated Capital Cost: $1,746,000
Round To: $1,700,000

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative II   Sub-Basin Thornton Creek

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
36	Pipe	36"	900'			Parallel Pipe	42"	$71,000
115	Pipe	12"	2,400'			Parallel Pipe	12"	$48,000
119	Pipe	15"	2,300'			Parallel Pipe	24"	$97,000
233	None					Diversion Pipe	54" 3,100'	$329,000
235	None					Diversion Pipe	72" 3,000'	$447,000
236	None					Diversion Pipe	54" 1,000'	$106,000
237	None					Diversion Pipe	72" 700'	$104,000
234	None					Diversion Pipe	84" 1,800'	$326,000
238	None					Diversion Pipe	144" 2,400'	$768,000
239	None					Diversion Pipe	84" 900'	$163,000
240	None					Diversion Pipe	66" 1,600'	$216,000
24	Culvert	Two-48" CMP	50'			Parallel Culvert	36"	$3,000
25	Channel	5'	1,600'	1:1	3'	Channel	7' width 3' depth 2:1 side slopes	$12,000
7	Channel	10'	500'	1:1	4'	Channel	Streambank protection	$8,000
5	Channel	10'	300'	1:1	4'	Channel	Streambank protection	$5,000
232	Holding Pond	2.0 AF				Holding Pond	8.5 AF	$155,000
233	None					Inlet/ Outlet	Diversion for 54"	$9,000

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative II Sub-Basin Thornton Creek

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
238	None					Inlet/ Outlet	Diversion for 54"	$20,000
235	None					Tunnel	3,000'	$500,000
240	None					Tunnel	1,600'	$267,000

The Estimated Capital Cost for each element includes Contractor profit, engineering, legal and contingencies. In addition, land purchase and severance costs are included where land is required. All costs are based upon June 1973 prices.

Total Estimated Capital Cost: $3,654,000

Round To: $3,700,000

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative III Sub Basin Thornton Creek

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
36	Pipe	36"	900'			Parallel Pipe	42"	$71,000
115	Pipe	12"	2,400'			Parallel Pipe	12"	$48,000
116	Pipe	15"	600'			Parallel Pipe	36"	$40,000
119	Pipe	15"	2,300'			Parallel Pipe	24"	$97,000
24	Culvert	Two-48" CMP	50'			Parallel Culvert	48"	$5,000
20	Culvert	84" CMP	100'			Parallel Culvert	36"	$7,000
241	None					Diversion Pipe	108" 2000'	$466,000
25	Channel	5'	1,600'	1:1	3'	Channel	8' width 3.5' depth 2:1 side slopes	$20,000
27	Channel	10'	3,000'	2:1	4'	Channel	Streambank protection	$22,000
23	Channel	10'	700'	1:1	3'	Channel	10' width 3.5' depth 2:1 side slopes	$8,000
7	Channel	10'	500'	1:1	4'	Channel	Streambank protection	$8,000
5	Channel	10'	300'	1:1	4'	Channel	Streambank protection	$5,000
232	Holding Pond	2.0 AF				Holding Pond	8.5 AF	$155,000
33	Channel	4'	1,100'	1:1	2'	Holding Pond	7 AF	$91,000
32	Channel	4'	700'	1:1	2'	Holding Pond	6 AF	$81,000
242	None	(Site of abandoned Lake City Sewage Treatment Plant)				Holding Pond	20 AF	$207,000
241	None					Inlet and Outlet Structures		$9,000

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

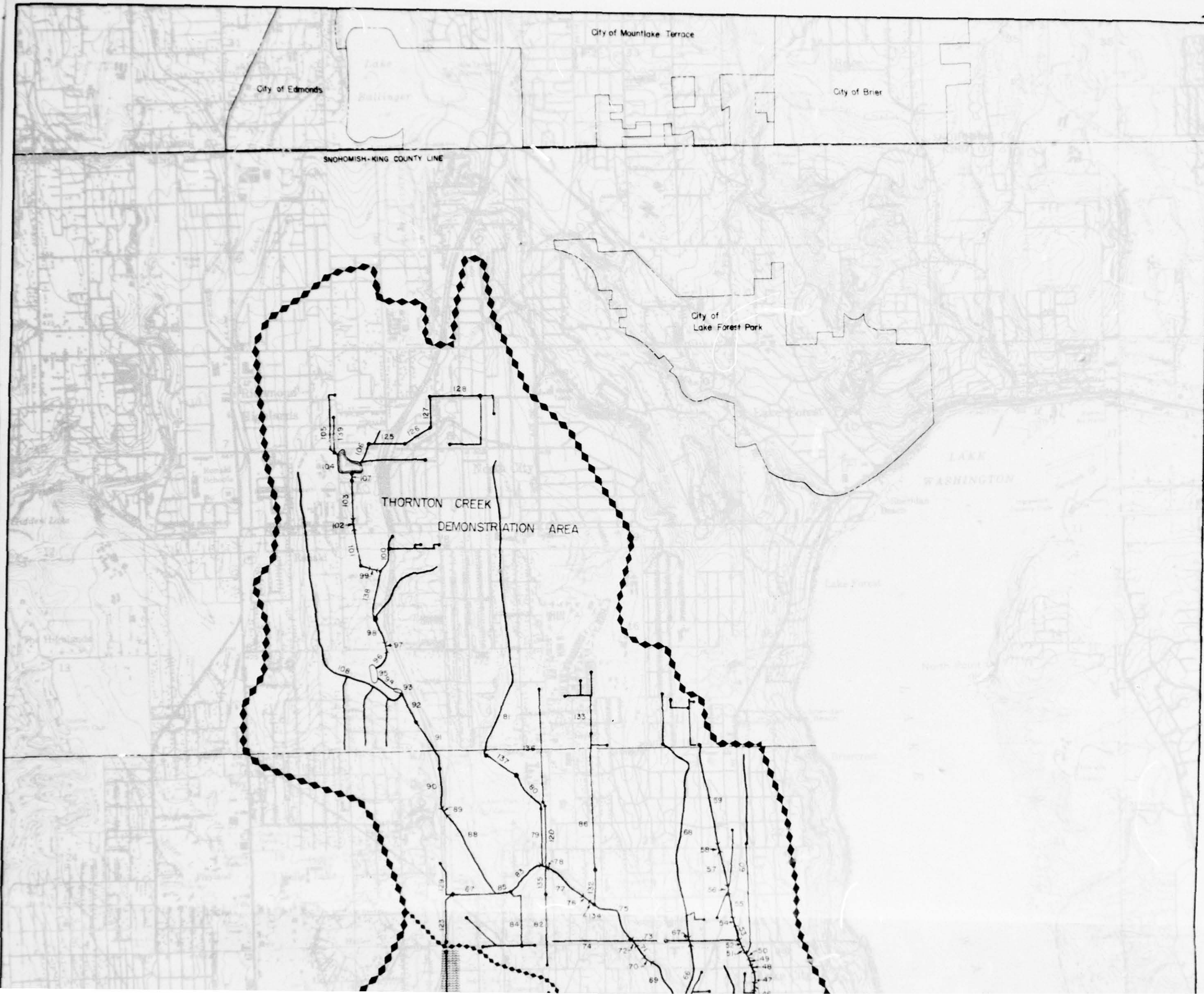
Alternative III   Sub-Basin Thornton Creek

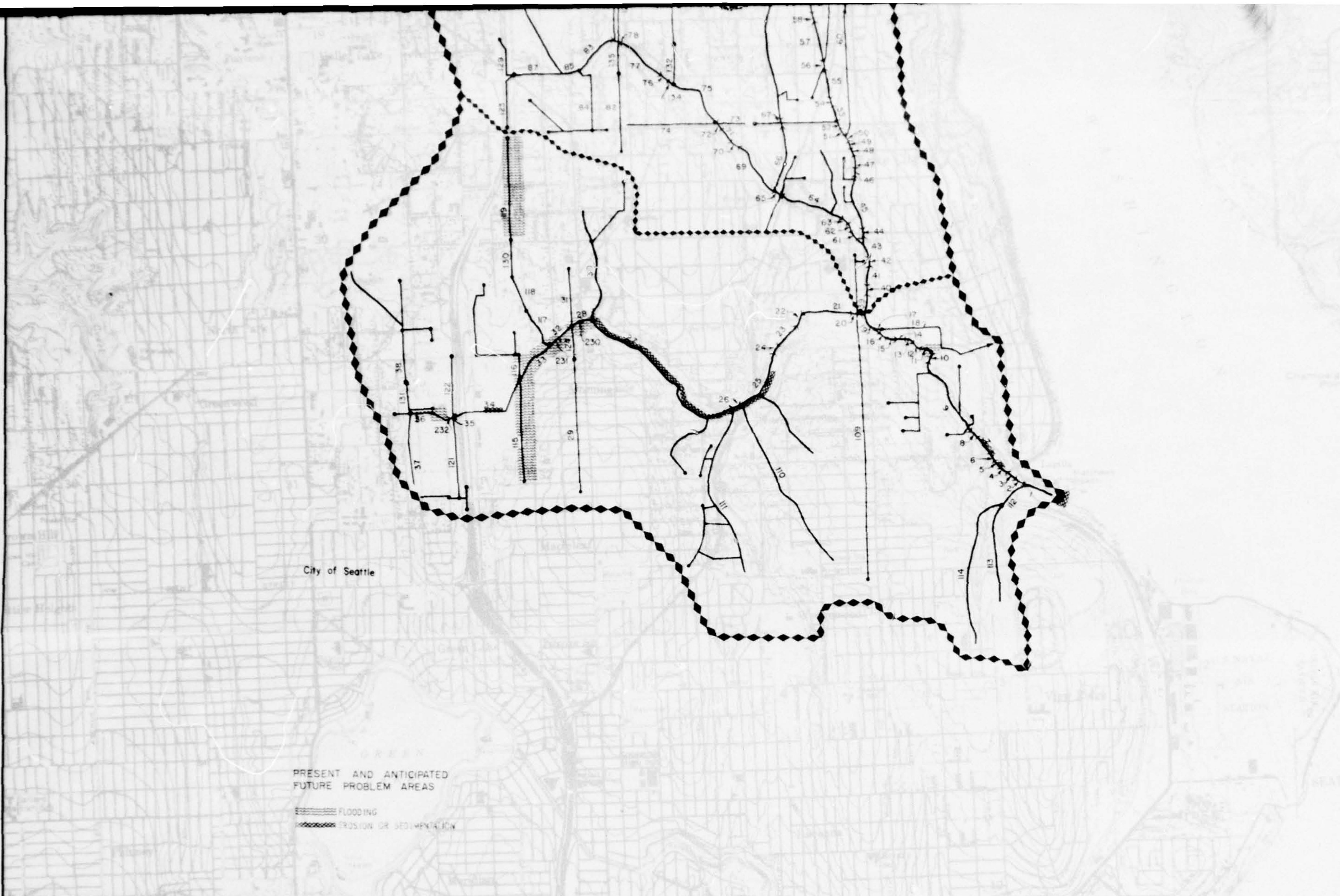
ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
20	None					Inlet and Outlet Structures	36"	$6,000
24	None					Inlet and Outlet Structures	48"	$8,000

The Estimated Capital Cost for each element includes Contractor profit, engineering, legal and contingencies. In addition, land purchase and severance costs are included where land is required. All costs are based upon June 1973 prices.

Total Estimated Capital Cost: $1,354,000

Round To: $1,400,000


City of Edmonds
City of Mountlake Terrace
City of Brier
SNOHOMISH-KING COUNTY LINE
City of
Lake Forest Park
LAKE
WASHINGTON
THORNTON CREEK
DEMONSTRATION AREA



LEGEND

SUB-BASIN BOUNDARY
EXISTING CHANNEL
EXISTING CONDUIT
MANHOLE, INLET, OR JUNCTION
CHANNEL OR CONDUIT DESIG 5
CITY LIMITS
COUNTY (METRO) BOUNDARY
LEVEE
CULVERT
HOLDING POND OR LAKE

1/2 1/4 0 1
MILES
1000 500 0 4000
FEET

NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

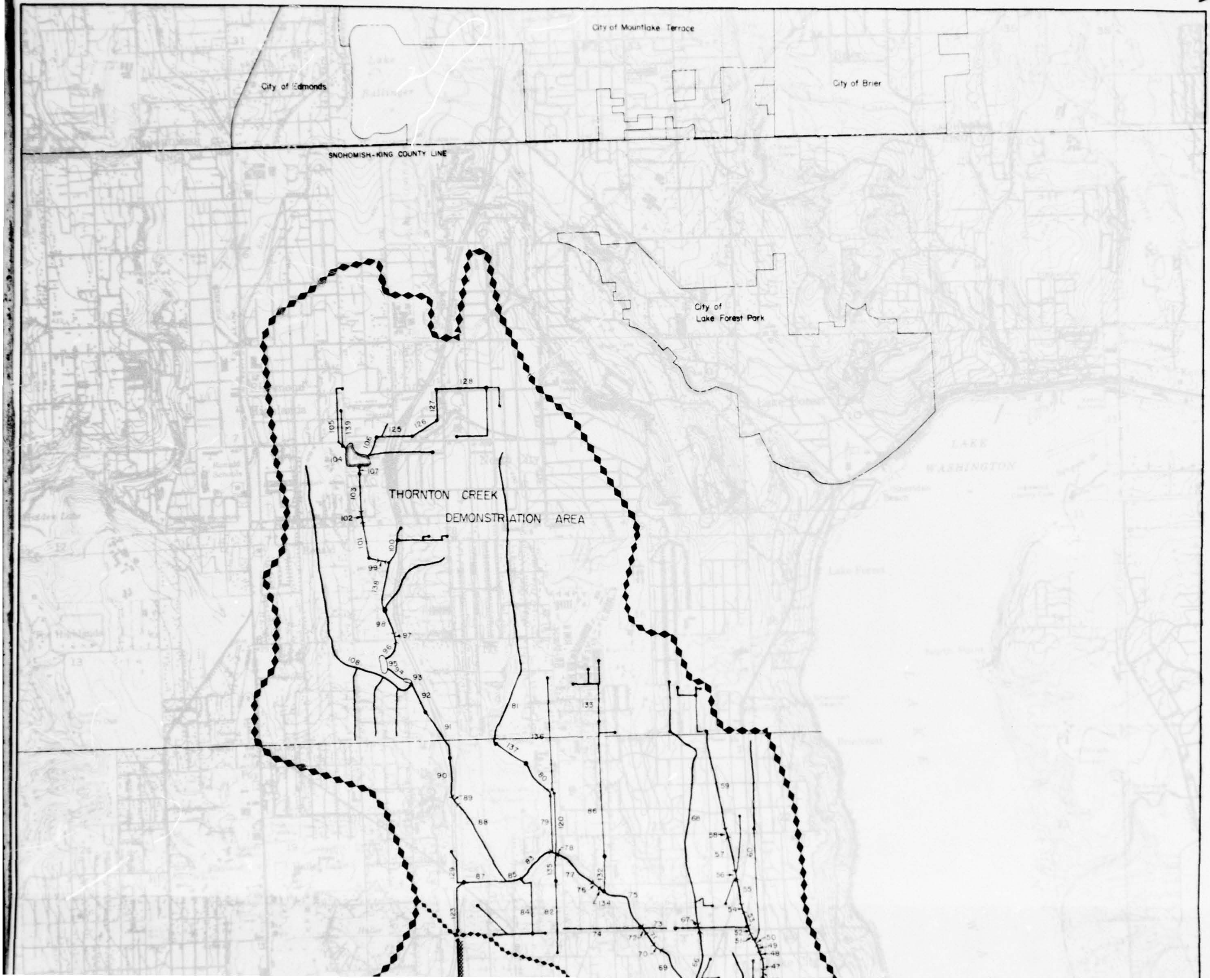
THORNTON CREEK

PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

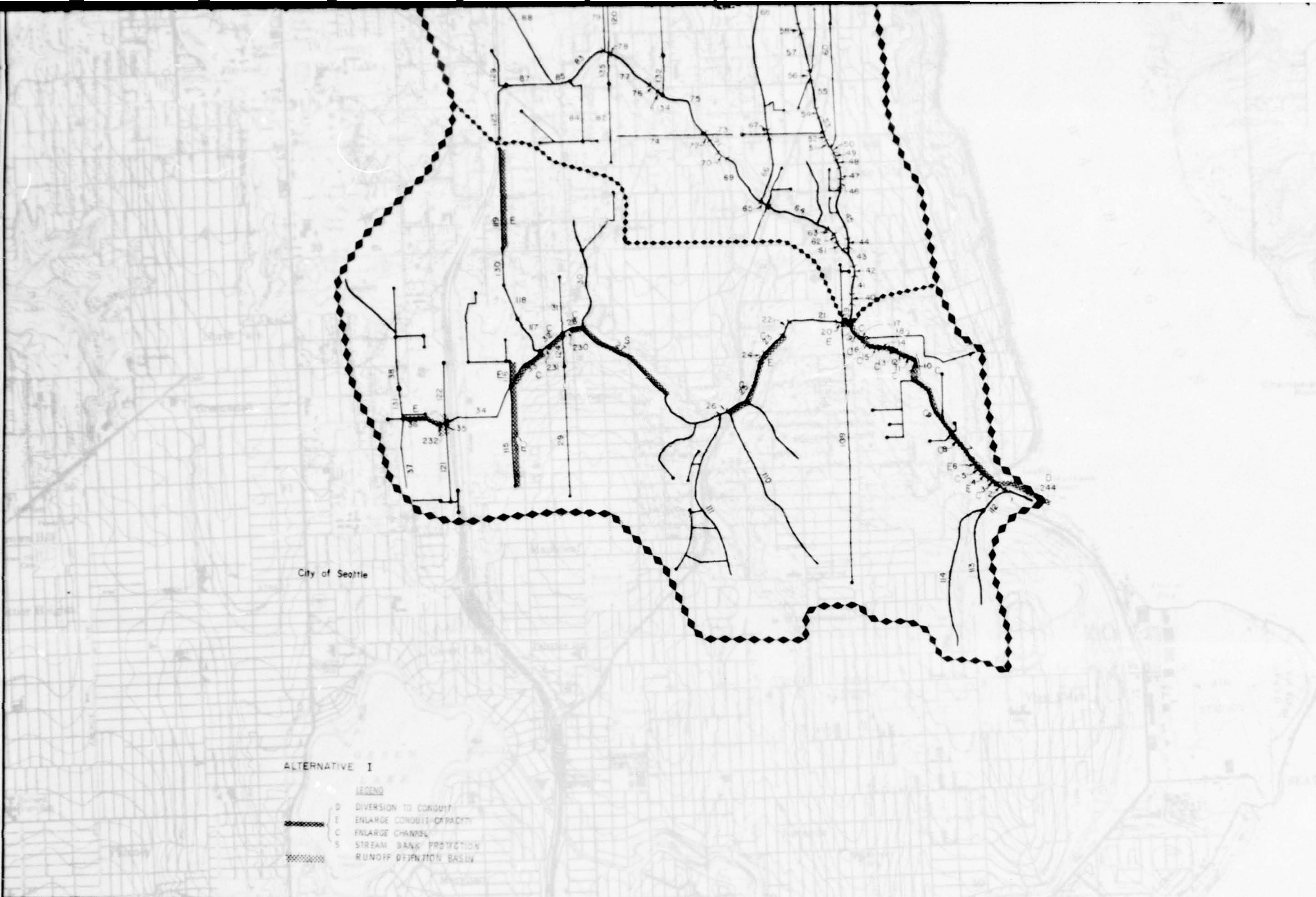
KRAMER, CHIN AND MAYO, INC
WATER RESOURCES ENGINEERS, INC
YODER, TROTTER, ORLOB & ASSOCIATES

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO E-26-1-161 SHEET 1 OF 1



City of Mountlake Terrace
City of Edmonds
City of Brier
SNOHOMISH-KING COUNTY LINE
City of Lake Forest Park
LAKE WASHINGTON
THORNTON CREEK DEMONSTRATION AREA



LEGEND

- SUB-BASIN BOUNDARY
- EXISTING CHANNEL
- EXISTING CONDUIT
- MANHOLE, INLET, OR JUNCTION
- CHANNEL OR CONDUIT DESIG. 5
- CITY LIMITS
- COUNTY (METRO) BOUNDARY
- LEVEE
- CULVERT
- HOLDING POND OR LAKE

N

MILES: 1/2, 1/4, 0, 1

FEET: 1000, 500, 0, 4000

NO.	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

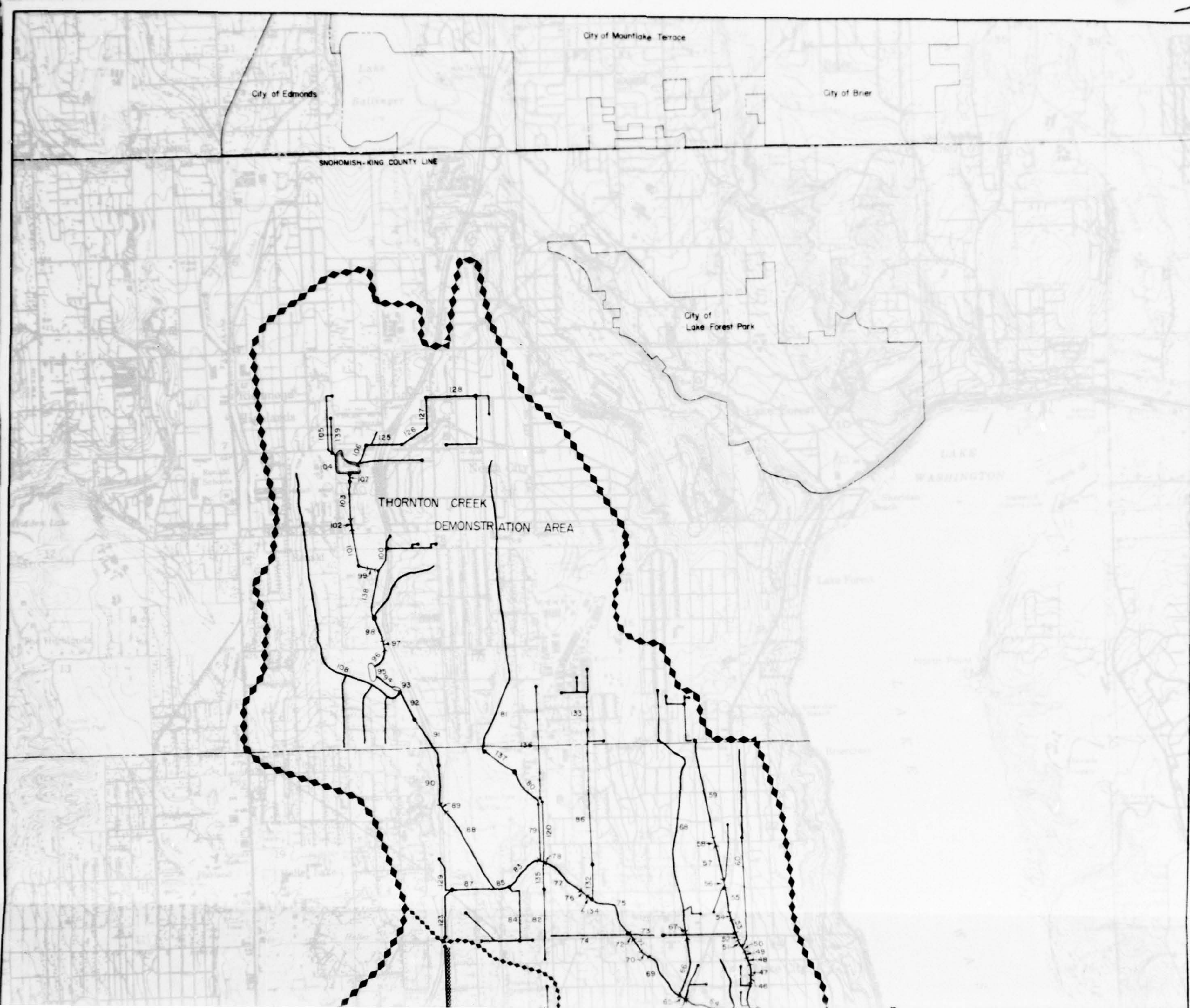
THORNTON CREEK

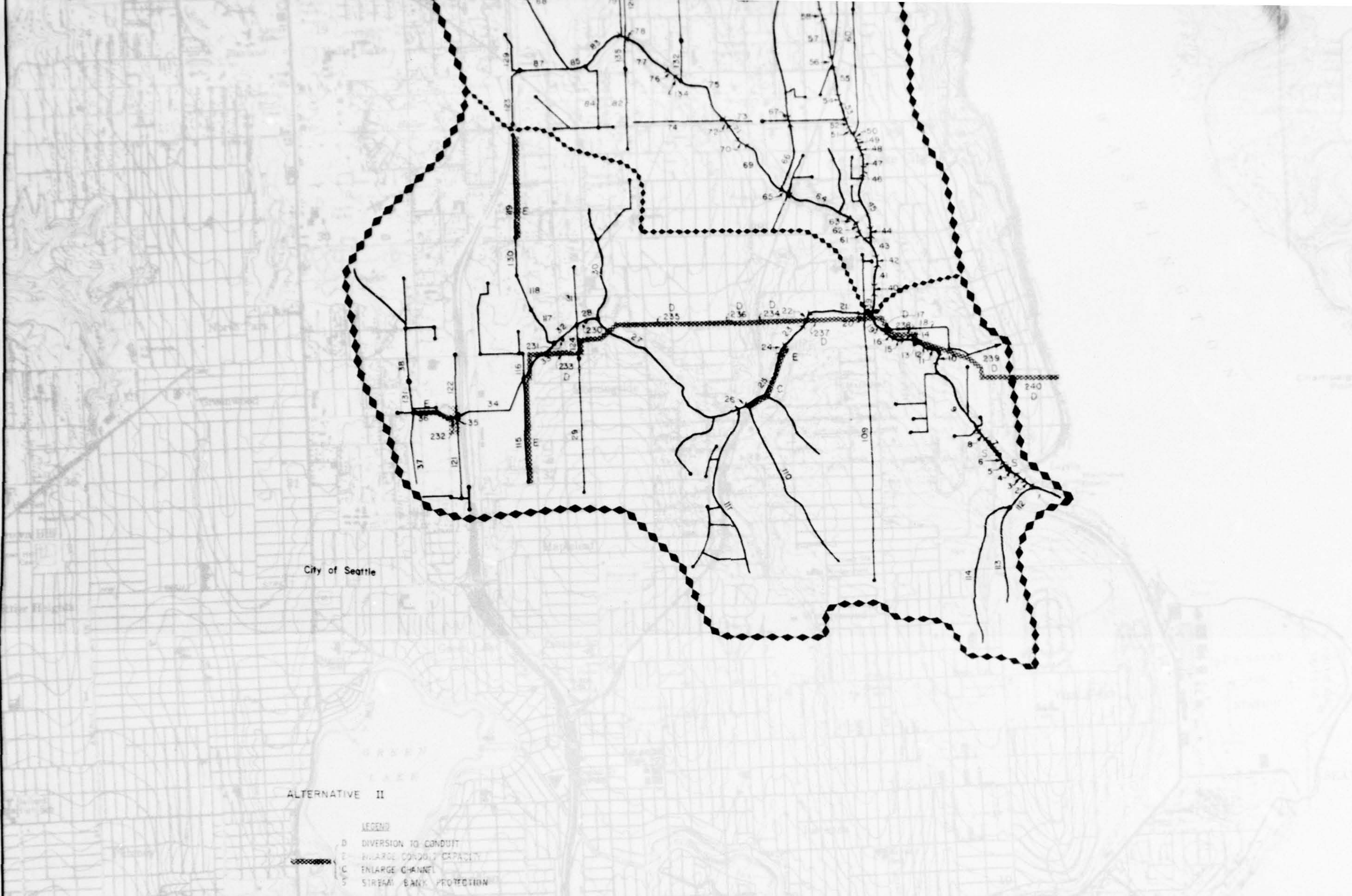
PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

KRAMER, CHIN AND MAYO, INC.
WATER RESOURCES ENGINEERS, INC.
YODER, TROTTER, ORLOB & ASSOCIATES

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO. E-26-1-161 SHEET 1 OF 1


City of Edmonds
City of Mountlake Terrace
City of Brier
SNOHOMISH-KING COUNTY LINE
City of
Lake Forest Park
THORNTON CREEK
DEMONSTRATION AREA



LEGEND

SUB-BASIN BOUNDARY
EXISTING CHANNEL
EXISTING CONDUIT
MANHOLE, INLET, OR JUNCTION
CHANNEL OR CONDUIT DESIG. 5
CITY LIMITS
COUNTY (METRO) BOUNDARY
LEVEE

CULVERT
HOLDING POND OR LAKE

N

1/2 1/4 0 1
MILES
1000 500 0 4000
FEET

NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

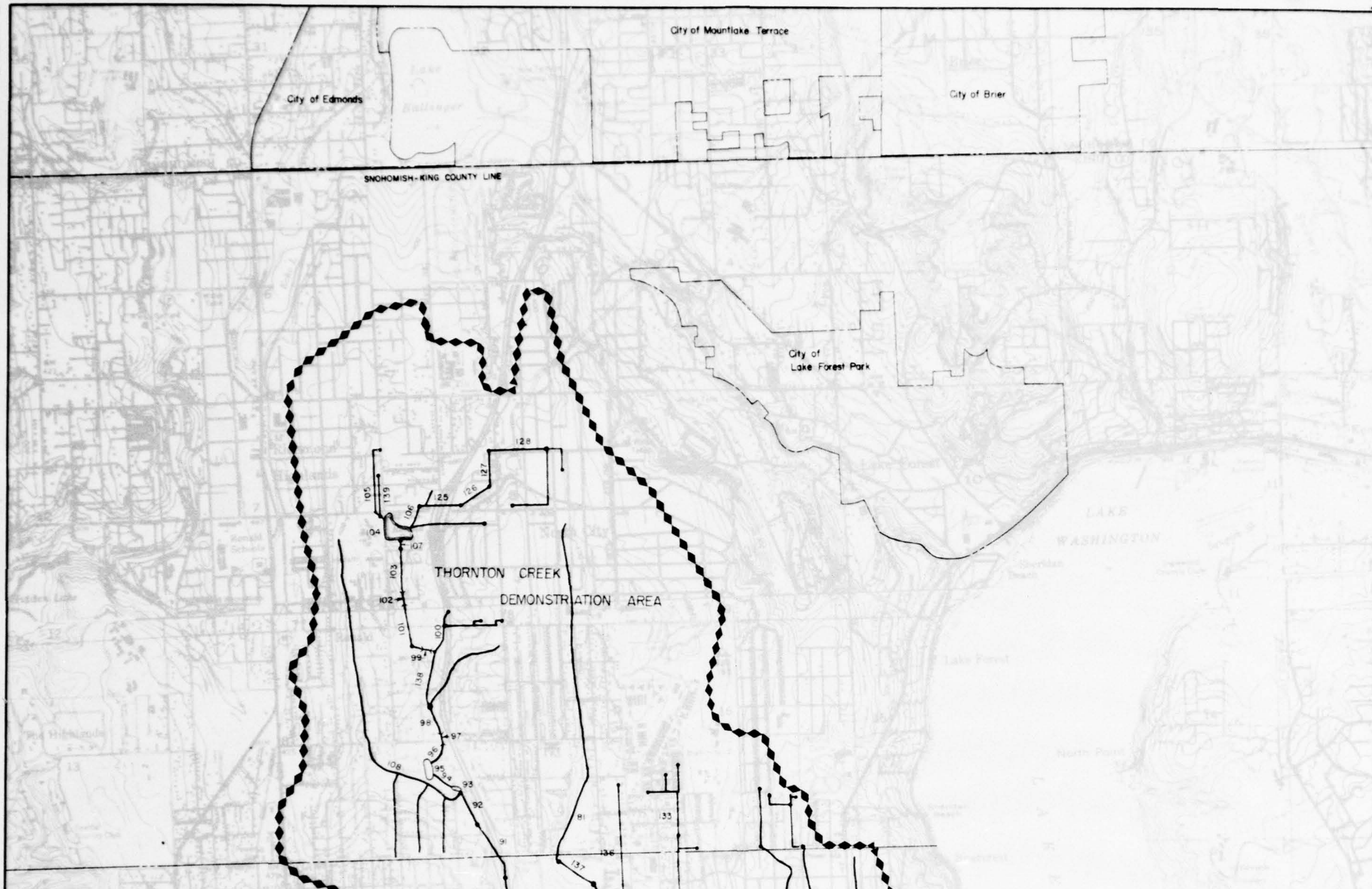
THORNTON CREEK

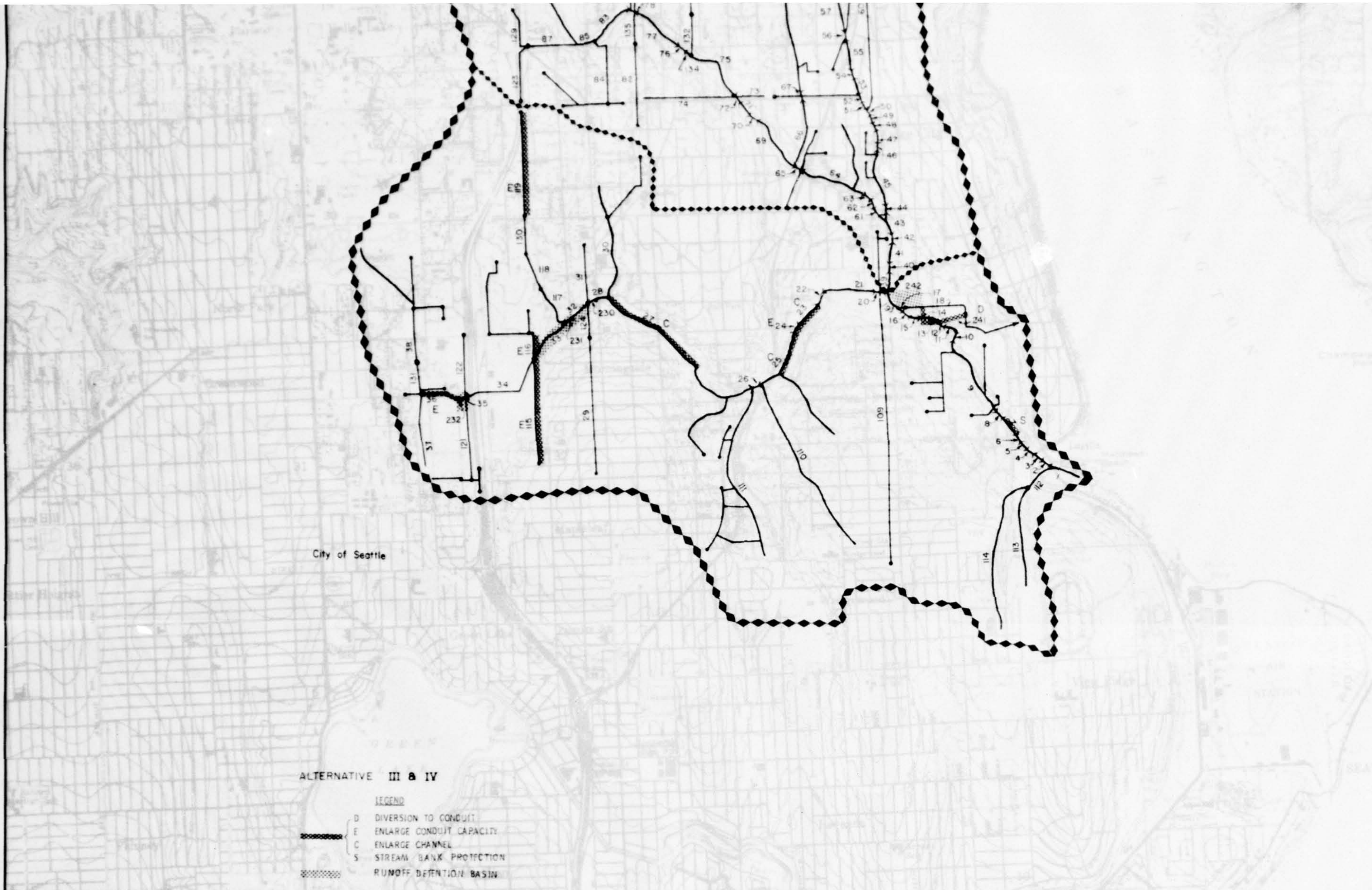
PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

KRAMER, CHIN AND MAYO, INC.
WATER RESOURCES ENGINEERS, INC.
YODER, TROTTER, ORLOB & ASSOCIATES

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO. E-26-1-161 SHEET 1c OF 1


City of Edmonds
City of Mountlake Terrace
City of Brier
SNOHOMISH-KING COUNTY LINE
City of
Lake Forest Park
LAKE
WASHINGTON
THORNTON CREEK
DEMONSTRATION AREA



LEGEND

- SUB-BASIN BOUNDARY
- EXISTING CHANNEL
- EXISTING CONDUIT
- MANHOLE, INLET, OR JUNCTION
- CHANNEL OR CONDUIT DESIG. 5
- CITY LIMITS
- COUNTY (METRO) BOUNDARY
- LEVEE
- CULVERT
- HOLDING POND OR LAKE

N

1/2 1/4 0 1 MILES

1000 500 0 4000 FEET

NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

THORNTON CREEK

PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

KRAMER, CHIN AND MAYO, INC.
WATER RESOURCES ENGINEERS, INC.
YODER, TROTTER, ORLOB & ASSOCIATES

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO. E-26-1-161 SHEET 1a OF 1

2

REGIONAL SUB-BASIN C-14

MERCER SLOUGH

GENERAL DESCRIPTION

The Mercer Slough Sub-Basin is located between Lake Washington and Lake Sammamish. It is traversed by Interstate 90 and Interstate 405. The sub-basin lies in a north-south direction with Mercer Slough draining south into Lake Washington at Interstate 90. Approximately 89% of the sub-basin is within the City of Bellevue and the remainder is in King County, 5%, Redmond 4%, and Kirkland 2%.

Geography of the sub-basin is typical of the central Puget Sound region with moderately rolling hills, gullies, and wetlands. Elevations range from more than 500 ft. to 15 ft. above sea level at Lake Washington.

Principal streams of the system are (1) Mercer Slough proper, the broad wetland receiving basin which flows south into Lake Washington; (2) Richards Creek, which flows north through Eastgate and the uplands of the south; (3) Kelsey Creek, which flows first north, and then south to drain central Bellevue; and (4) Valley Creek, which flows south and drains portions of Bellevue, Kirkland and Redmond. Stream length over the longest distance is 11.2 miles.

Streams	Category	Drainage Area	Discharge
Mercer Slough	III	7.4 sq. mi.	Lake Washington
Richards Creek	III	3.7 sq. mi.	Mercer Slough

Kelsey Creek has been designated as a demonstration area and has received a separate evaluation in this appendix.

Present development of the entire sub-basin is a mixture of residential , commercial, industrial, institutional and transportation uses plus some agricultural, public open space and vacant land. This sub-basin has passed the 50% development mark and now is approximately 33% vacant land.

PERCENT OF SUB-BASIN AREA IN SPECIFIED LAND USE

Land Use	Existing (1970-72)	P.S.G.C. Land Use Projection Comprehensive	Corridor
Single Family	66	63	68
Multiple Family	1	3	3
Commercial/Services	2	15	10
Govt. and Educ.	2	3	3
Industrial	1	5	5
Parks/Dedicated Open Space	5	10	10
Agriculture	2		
Airports, Railyards, Freeways, Highways	1	1	1
Unused Land	20		
Water			
Total	100	100	100
Total Impervious Area	25	40	40

Patterns of land use in this sub-basin are defined and future development generally should tend to fill in the voids. Further development in Mercer Slough proper, such as Bellefield Park, an industrial area, will eliminate this portion of the slough's natural drainage system. Likewise, massive development projects, such as the proposed Evergreen East, without adequate runoff controls, will greatly impact the drainage system.

The PSGC-year 2000 Comprehensive and Corridor Plans both project 100% development within the sub-basin with significant increases of commercial and industrial land use.

Public concern over the future of the Mercer Slough Sub-Basin is intense. The City of Bellevue, with jurisdictional control over most of the sub-basin, has recently created a drainage utility that designates the Mercer Slough system of streams as a part of a drainage utility system that will make use of the various streams and wetlands in their natural state. Interest in the Mercer Slough system as a natural element to be preserved is expressed by the on-going involvement of the Bellevue Citizens Advisory Committee on Stream Resources, a group created by the Bellevue City Council.

NATURE OF EXISTING DRAINAGE SYSTEM

The existing drainage system is a combination of the natural streams, two lakes, the wetland areas of Mercer Slough proper and Kelsey Creek and extensive man-made facilities, including curbs, gutters, culverts and pipes. A major portion of Mercer Slough proper has been channelized and dredging is periodically necessary.

The Mercer Slough system has a diminishing potential as an urban greenway as development encroaches upon the streambanks. The stream has been incorporated into development of numerous residential properties and access along the stream is inhibited by barriers such as bridges, culverts and fences. There is an existing population of cutthroat trout and coho salmon that require high-quality water for survival. However, other stream life evident in the system is of the pollution-tolerant variety that indicates a degradation of stream ecology. The sub-basin is served by Metro for sanitary sewerage.

DRAINAGE PROBLEMS

Drainage problems within the Mercer Slough area are concentrated in two general areas; the Richards Slough area north of Kamber Road and the main channel of Mercer Slough between I-405 and Lake Washington.

Overbank flooding occurs in the area of the Factoria industrial area north of I-405 and east of Richards Road. Flood flows exceed the capacity of the culverts at Kamber Road. Channel slopes begin to flatten north of Kamber Road and the capacity of the downstream channels are reduced.

The slough area between Kelsey Creek and Richards Creek experiences general overland flow when the runoff exceeds the channel capacity. The Interlake Connector serves as a barrier between the two watersheds until approximately one half mile above the I-405 culvert.

Some minor flooding of storm drains occurs in developed parts of the Mercer Slough but the major problem is focused at the main Mercer Slough channel which floods over the banks.

Erosion within the sub-basin seems to be controlled by the existing holding pond above I-405 on Richards Creek which drains the Somerset area. The stream gradients are very steep in this area and the holding pond settling basin requires cleaning virtually every year.

Both the year 2000 Comprehensive and Corridor Land Use Plans indicate a general urbanization of the Mercer Slough sub-basin. The results of hydrologic analyses of these plans indicates no significant difference between the Comprehensive and Corridor Land Use Plans. Therefore, the drainage alternatives presented herein are applicable to both plans. The existing drainage problems will become more severe

because of increases in impervious areas and resultant faster runoff. The total impervious area in this sub-basin under either land use projections will increase from an existing 25% level to approximately 40%, as shown by the table of projected land uses.

BASIC ISSUES AND STATUS OF DRAINAGE PLANNING

As cited above, the City of Bellevue has designated the Mercer Slough system in its natural state as a part of the City's drainage utility. The utility would assess all sub-basin property owners a monthly service charge based upon the amount of runoff from impervious surfaces. The City also is considering alternative land-use plans based upon sub-basin drainage characteristics. The execution of these actions is critical as the Mercer Slough system is in a deteriorating state. Bellevue also has a unique "clearing and grading" ordinance that requires control of runoff from properties being developed.

The Committee on Stream Resources has aided the Bellevue City staff in an inventory of the stream system, its ecology and problems. A National Science Foundation grant to the University of Washington in 1971 also produced detailed analysis of Kelsey Creek ecology. In 1972, the Bellevue Planning Department undertook a very progressive program for development of future land-use alternatives based upon drainage-basin constraints. This effort was followed by development of the Drainage Basin Management Plan.

Staff members from the City of Bellevue Public Works Department have reviewed the initial alternative plans for drainage developed by this RIBCO study for the Mercer Slough Sub-Basin.

ALTERNATIVE PLANS FOR PROPOSED DRAINAGE CONTROL

The existing drainage system of the Mercer Slough Sub-Basin, as described by local agencies, was evaluated by computer simulation that applied the region's 10-year storm to P.S.G.C. year 2000 land use. Drainage problems thus identified were analyzed and possible solutions were provided for development of drainage-control alternative plans as described below.

ALTERNATIVE PLAN I

General Concept

For purposes of comparing drainage alternatives and their costs, the traditional method of channelization is investigated as Alternative Plan I. The drainage system will be enlarged to pass peak flows indicated by the future land-use plan. The channels and conduits will be enlarged, and streambanks protected where required.

Major Features

Almost the entire system would require enlargement or stream bank protection. The channel through the Kelsey Creek-Richards Creek slough area between Kamber Road and I-405 would require large channel capacities. The culverts beneath the freeway also would require enlargement. Mercer Slough would require very large channels in the flatter downstream reaches near Lake Washington to accommodate the flows. Storm drains carrying runoff from the N.E. 8th Street interchange area, and the area west of the freeway would also require enlargement.

Cost

The cost for Alternative Plan I is estimated to be $5,600,000.

ALTERNATIVE PLAN II

General Concept

This alternative is composed of two basic elements. On-site runoff control will be used to reduce runoff under future developments to that presently experienced. Flood-plain zoning is recommended in areas where flooding will occur to prevent damage to existing development.

Major Features

On-site runoff control will be provided throughout the watershed for all future development. Runoff will be limited to present levels in order to relieve the demand upon most existing facilities. Flood-plain zoning will be needed in Mercer Slough and the Kelsey Creek-Richards Creek wetland areas.

Enlargement of storm drains and road culverts is recommended where ponding is not considered appropriate. Culvert enlargement is anticipated at Kamber Road, for some storm drains in the Woodridge area, and on the tributary to Mercer Slough that drains the N.E. 8th interchange area.

Streambank protection is recommended for erodible areas in the Somerset area. The settling pond above I-405 collects eroded material thereby reducing the sedimentation process in the lower basin and it provides some attenuation of flows.

Cost

The estimated cost for this alternative is estimated to be $700,000.

PEAK FLOW COMPARISONS

The following table indicates 10-year peak flows with existing

facilities and with alternative drainage management solutions for the year 2000.

COMPARISON OF 10-YEAR PEAK FLOWS
(Cubic Feet Per Second)

Location	Existing Facilities #	Alternative Plan I	Alternative Plan II
Richards Creek	115	1,090	500
below Kamber Rd.	115	1,090	500
Mouth of Kelsey Creek	415	1,730*	430**
Confluence of Kelsey Creek & Richards Creek	-	2,600	775
Mercer Slough below I-405	230	2,850	960
Mouth of Mercer Slough	210	2,700	830

#Flows limited by existing system capacity.
*Flow based upon Kelsey Creek Alternative I.
**Flow based upon Kelsey Creek Alternative II.

ENVIRONMENTAL ASSESSMENT OF ALTERNATIVE PLANS

Field inspections were made of the suggested alternative plans for this sub-basin. This procedure was followed throughout the RIBCO Study in developing alternative plans for the various regional sub-basins. The inspections were based on the alternative evaluation procedure which identified 34 unique criteria grouped in general categories as follows: 1) Effectiveness, 2) Human Values, 3) Environmental Factors, 4) Implementation, and 5) Resource Requirements. The various structural solutions were checked against the appropriate criteria and the various non-structural solutions were reviewed for their relationship to existing and probable future developments. The criteria rating total for Alternative Plan I, which employs channelization, streambank protection and enlarged conduit, was a minus 35 on a scale ranging from positive 108 to negative 108. The total evaluation rating for Alternative Plan II, which employs runoff control, flood plain zoning, storage and limited channelization, was a plus 54.

Alternative Plan II received a positive rating for storm runoff control effectiveness, while Alternative Plan I received a negative

rating for effectiveness. The basic difference in this category was in the probable consequences of overcharge that is assumed to be quite severe under Alternative Plan I. Both alternative plans received positive ratings for preservation of human values, but Alternative Plan II was clearly superior in this regard. The visual quality of a natural stream system and multiple use potential were the primary factors in its high rating in this category. The two alternative plans received widely divergent scores for environmental factors, with Alternative Plan II receiving a high positive rating and Alternative Plan I receiving a low negative rating. Alternative Plan II clearly enhances water quality and groundwater recharge and also positively affects wildlife, aquatic life and vegetation. Alternative Plan I was either detrimental or ineffective in these areas. Only Alternative Plan II received a positive rating for implementation, this as a result of the general public acceptance in Bellevue of the approach to drainage management which utilizes a natural stream system and runoff control. Alternative Plan II also received a positive rating for resource requirements, primarily because of the insignificant amount of materials necessary to accomplish this alternative, and because of the multi-purpose land potentials. Alternative Plan I received a negative rating for resource requirements as it required extensive commitments of energy, materials, land and capital.

Alternative Plan II contains two critical elements. They are flood-plain zoning and runoff control. This treatment combination, if it is to be part of the chosen alternative, should be implemented as an early effort. Any additional portion of the sub-basin that develops without these combined controls will require more structural treatment than Alternative Plan II can accommodate. This issue should be brought to the attention of all citizens and their local agencies. There also are sacrifices involved with Alternative Plan II which requires that certain areas be flood-plain zoned. The areas so designated would be effectively removed from any future intensive land uses typical of urbanized areas.

Alternative Plan II is believed to be one example of a drainage management system that is consistent with the stated goals of the Bellevue Drainage Utility.

CONCLUSIONS

Alternative Plan II is clearly superior to Alternative Plan I, but immediate action would be required to protect and preserve the natural stream system. As pointed out above, this action would require runoff control for all future development as well as the designation of a flood plain within the sub-basin.

The City of Bellevue and King County should establish an effective agreement for development of a master drainage plan, that incorporates the provisions of Alternative Plan II. Both agencies should then move to implement and enforce the required runoff and flood-plain zoning

within their own jurisdictions.

The basic issue is which local agency or agencies will have jurisdiction and responsibility for control of urban drainage and related flood-damage problems. There also is the issue of the use or extent of use of land-use zoning control by and between King County and the City of Bellevue. In any case, the City of Bellevue should have responsibility for control of drainage in the Mercer Slough Sub-Basin, and that the City and County should have control of zoning, including flood-plain zoning, within their respective boundaries.

RUNOFF QUALITY SUMMARY
MERCER SLOUGH

BASED UPON A 10-YEAR STORM PRECEDED BY 15 DAYS WITH LITTLE OR NO RAINFALL#

LOCATION	ALTERNATIVE PLAN	PEAK FLOW (cfs)	CONCENTRATION AT PEAK FLOW*				
			BOD	TOTAL COLIFORM	NH_3	$NO_2 + NO_3$	PO_4
Mouth	I	2700	52	1.4×10^6	2.0	3.8	1.1
	II	750	37	$.8 \times 10^6$	1.3	2.7	.8

Less than a total of 0.5 inches of rainfall in any one day.
* Concentrations in mg/liter except total coliform which is in MPN/100 ml.

EVALUATION MATRIX

MERCER SLOUGH

ALTERNATIVES	SUB TOTAL	EFFECTIVENESS: Use of existing facilities	System reliability	System maintainability	System flexibility	Flood damage reduction	Consequences of overcharge	Erosion and sedimentation control	Cost/benefits ranking	SUB TOTAL	HUMAN VALUES: Urban quality (aesthetics)	Effect on land use	Displacement of people	Educational value	Community cohesion	Multiple use potential	Public health and safety	SUB TOTAL	ENVIRONMENTAL FACTORS: High flow conditions	Alteration of natural system	Effects on groundwater	Low flow conditions	Water quality	Construction disruption	Effects on wildlife	Effects on aquatic life	Effects on vegetation	SUB TOTAL	IMPLEMENTATION: Legislative requirements	Jurisdictional	Land acquisition	Public acceptance	Financing	Effects of no action	SUB TOTAL	RESOURCE REQUIREMENTS: Energy	Materials	Land	Capital	RATING TOTAL
CRITERIA WEIGHT		1	4	3	2	4	4	4	2		4	2	2	1	3	3	4		4	[illegible]	4	4	4	2	4	4	4		4	4	2	4	4	3		3	3	2	2	
I	-5									+1								-18										-3							-10					-35
II	+14									+11								+24										+1							+4					+54

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative I   Sub Basin Mercer Slough

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
53	Pipe	24"	700'			Parallel Pipe	18"	$21,000
52	Pipe	30"	1,500'			Parallel Pipe	18"	$45,000
213	Channel	6'	600'	1:1	3'	Channel	Clean channel Streambank protection	$13,000
212	Culvert	4' rough	60'			Replacement Culvert	48" smooth	$13,000
49	Pipe	30"	2,500'			Parallel Pipe	24"	$105,000
47	Channel	4'	1,350'	1:1	2'	Channel	5' width 2' depth 1:1 side slopes Streambank protection	$28,000
210	Pipe	48"	420'			Parallel Pipe	36"	$28,000
45	Culvert	4'	100'	0	3'	Replacement Culvert	6' x 3'	$27,000
44	Channel	4'	700'	.5:1	2'	Channel	10' width 4' depth .5:1 side slopes Streambank protection	$20,000
40	Culvert	48"	100'			Replacement Culvert	60"	$22,000
39	Culvert	48"	60'			Replacement Culvert	54"	$15,000
226	Channel	4'	1,100'	0	3'	Channel	25' width 3' depth 2:1 side slopes Streambank protection	$63,000
38	Culvert	4'	100'	0	3'	Replacement Culvert	12' x 3'	$42,000
37	Channel	6'	500'	.5:1	4'	Channel	20' width 4' depth 1:1 side slopes Streambank protection	$18,000
36	Channel	8'	2,000'	1:1	4'	Channel	27' width 4' depth 1:1 side slopes Streambank protection	$85,000
35	Culvert	60"	50'			Replacement Culvert	30' x 5'	$54,000
224	Channel	8'	900'	1:1	4'	Channel	70' width 4' depth 1:1 side slopes	$56,000

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative I Sub-Basin Mercer Slough

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
207	Culvert	21'	100'	0	3.5'	Replacement Culvert	35' x 4'	$115,000
34	Channel	15'	2,300'	1:1	6'	Channel	45' width 6' depth 1:1 side slopes	$100,000
33	Channel	20'	1,100'	2:1	7'	Channel	65' width 7' depth 2:1 side slopes	$83,000
201	Channel	25'	400'	2:1	8.5'	Channel	50' width 8.5' depth 1:1 side slopes	$12,000
32	Culvert	120" pipe and 10' x 4' box culvert	700'			Parallel Culvert	16' x 10'	$480,000
31	Channel	40'	700'	1:1	5'	Channel	80' width 6' depth 1:1 side slopes	$49,000
26	Pipe	18"	1,900'			Parallel Pipe	27"	$89,000
223	Channel	3'	1,150'	0	3'	Channel	8' width 3' depth 2:1 side slopes Streambank protection	$82,000
23	Channel	3'	650'	0	3'	Channel	3' width 3' depth 2:1 side slopes Streambank protection	$42,000
22	Pipe	66"	1,170'			Parallel Pipe	42"	$92,000
21	Pipe	24"	800'			Parallel Pipe	21"	$29,000
20	Channel	20'	2,300'	1:1	3'	Channel	40' width 3' depth 1:1 side slopes	$134,000
19	Channel	40'	1,000'	1:1	3'	Channel	120' width 3' depth 1:1 side slopes	$143,000
15E	Channel	50'	2,600'	1:1	3'	Channel	170' width 3' depth 1:1 side slopes	$557,000
14	Pipe	18"	1,300'			Replacement Pipe	24"	$55,000
13	Pipe	30"	300'			Replacement Pipe	30"	$16,000
10	Pipe	18"	800'			Replacement Pipe	24"	$34,000

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative I   Sub Basin Mercer Slough

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
9	Pipe	30"	200'			Parallel Pipe	24"	$12,000
7	Channel	50'	900'	1:1	3'	Channel	600' width 3' depth 1:1 side slopes	$389,000
6	Pipe	18"	1,500'			Replace-ment Pipe	24"	$63,000
3	Channel	50'	1,800'	1:1	3'	Channel	650' width 3' depth 1:1 side slopes Land cost not included	$720,000
2	Channel	30'	1,600'	1:1	3'	Channel	650' width 3' depth 1:1 side slopes Land cost not included	$660,000
1	Channel	20'	1,400'	1:1	3'	Channel	650' width 3' depth 1:1 side slopes Land cost not included	$588,000
43	Channel	4'	1,000'	0	2'	Channel	4' width 4' depth 1:1 side slopes Streambank protection	$37,000
62	Channel	3'	2,300'	2:1	3'	Channel	Streambank protection	$77,000
61	Channel	4'	3,600'	1:1	3'	Channel	Streambank protection	$76,000
59	Channel	10'	1,800'	1:1	3.5'	Channel	Streambank protection	$45,000
58	Channel	1'	2,500'	1:1	3.5'	Channel	Streambank protection	$62,000
57	Channel	1'	1,000'	1:1	2'	Channel	Streambank protection	$25,000
54	Channel	20'	3,500'	1:1	2'	Channel	Streambank protection	$53,000
215	Channel	6'	600'	5:1	3'	Channel	Streambank protection	$10,000
12	Channel	3'	900'	1:1	3'	Channel	Streambank protection	$19,000
4	Channel	3'	600'	1:1	3'	Channel	Streambank protection	$13,000

The Estimated Capital Cost for each element includes Contractor profit, engineering, legal and contingencies. In addition, land purchase and severance costs are included where land is required. All costs are based upon June 1973 prices.

Total Estimated Capital Cost: $5,616,000
Round To: $5,600,000

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative II Sub-Basin Mercer Slough

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
53	Pipe	24"	700'			Parallel Pipe	12"	$14,000
41	Channel	4'	500'	.75:1	6'		Flood plain zone	-0-
226	Cnannel	4'	1,100'	0	3'	Channel	12' width 3' depth 1:1 side slopes Streambank protection	$52,000
38	Culvert	4'	100'	0	3'	Replacement Culvert	7' x 3'	$29,000
37	Channel	6'	500'	.5:1	4'		Flood plain zone	-0-
49	Pipe	30"	2,500'			Parallel Pipe	18"	$75,000
47	Channel	4'	1,350'	1:1	2'	Channel	Cleaning Streambank protection	$21,000
44	Channel	4'	700'	.5:1	2'		Flood plain zone	-0-
36	Channel	8'	2,000'	1:1	4'		Flood plain zone	-0-
35	Culvert	60"	50'			Replacement Culvert	18' x 5'	$34,000
224	Channel	8'	900'	1:1	4'		Flood plain zone	-0-
34	Channel	15'	2,300'	1:1	6'		Flood plain zone	-0-
71	Channel	40'	700'	1:1	5'		Flood plain zone	-0-
26	Pipe	18"	1,900'			Parallel Pipe	27"	$72,000
223	Channel	3'	1,150'	0	3'	Channel	7' width 3' depth 1:1 side slopes Flood plain zone	$16,000
19	Channel	40'	1,000'	1:1	3'		Flood plain zone	-0-
15E	Channel	50'	2,600'	1:1	3'		Flood plain zone	-0-

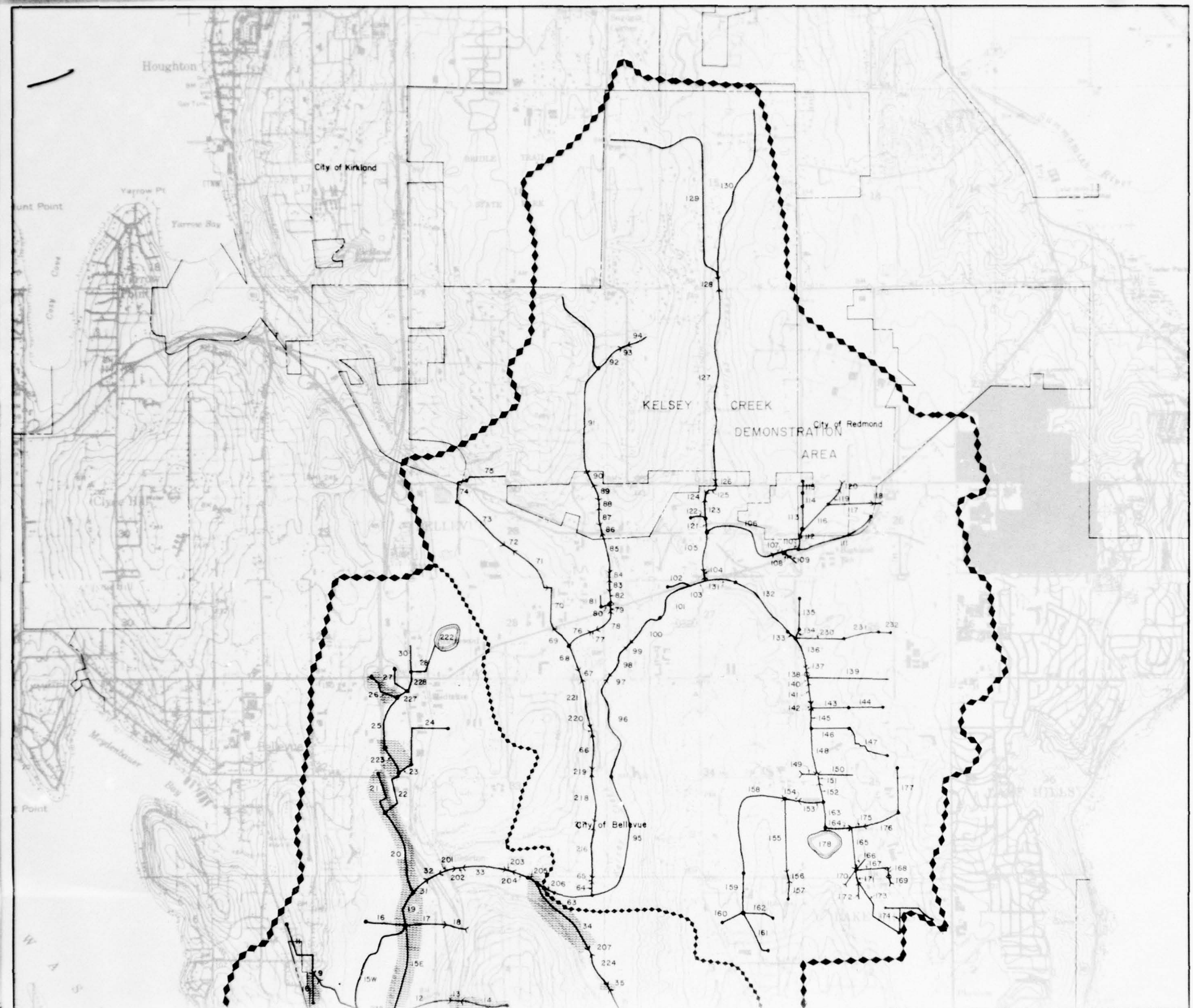
RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

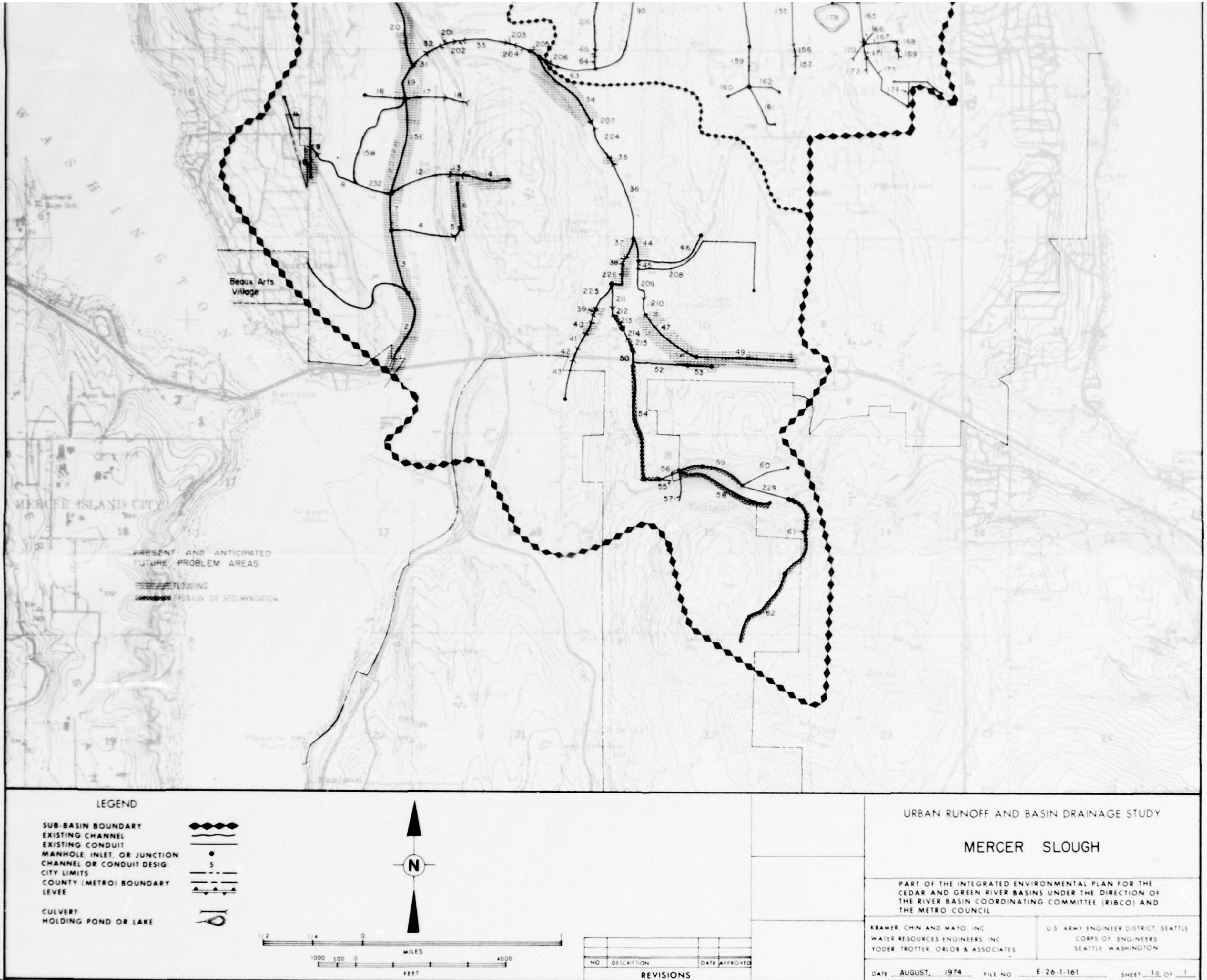
Alternative II Sub-Basin Mercer Slough

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
7	Channel	50'	900'	1:1	3'		Flood plain zone	-0-
3	Channel	50'	1,800'	1:1	3'		Flood plain zone	-0-
2	Channel	30'	1,600'	1:1	3'		Flood plain zone	-0-
1	Channel	20'	1,400'	1:1	3'		Flood plain zone	-0-
10	Pipe	18"	800'			Parallel Pipe	15"	$20,000
232	Channel	50'	1,700'	1:1	3'		Flood plain zone	-0-
62	Channel	3'	2,300'	2:1	3'	Channel	Streambank protection	$77,000
61	Channel	4'	3,600'	1:1	3'	Channel	Streambank protection	$76,000
59	Channel	10'	1,800'	1:1	3.5'	Channel	Streambank protection	$45,000
58	Channel	1'	2,500'	1:1	3.5'	Channel	Streambank protection	$62,000
57	Channel	1'	1,000'	1:1	2'	Channel	Streambank protection	$25,000
54	Channel	20'	3,300'	1:1	2'	Channel	Streambank protection	$53,000
215	Channel	6'	600'	.5:1	3'	Channel	Streambank protection	$10,000
213	Channel	6'	600'	1:1	3'	Channel	Streambank protection	$13,000
12	Channel	3'	900'	1:1	3'	Channel	Streambank protection	$19,000
4	Channel	3'	600'	1:1	3'	Channel	Streambank protection	$13,000

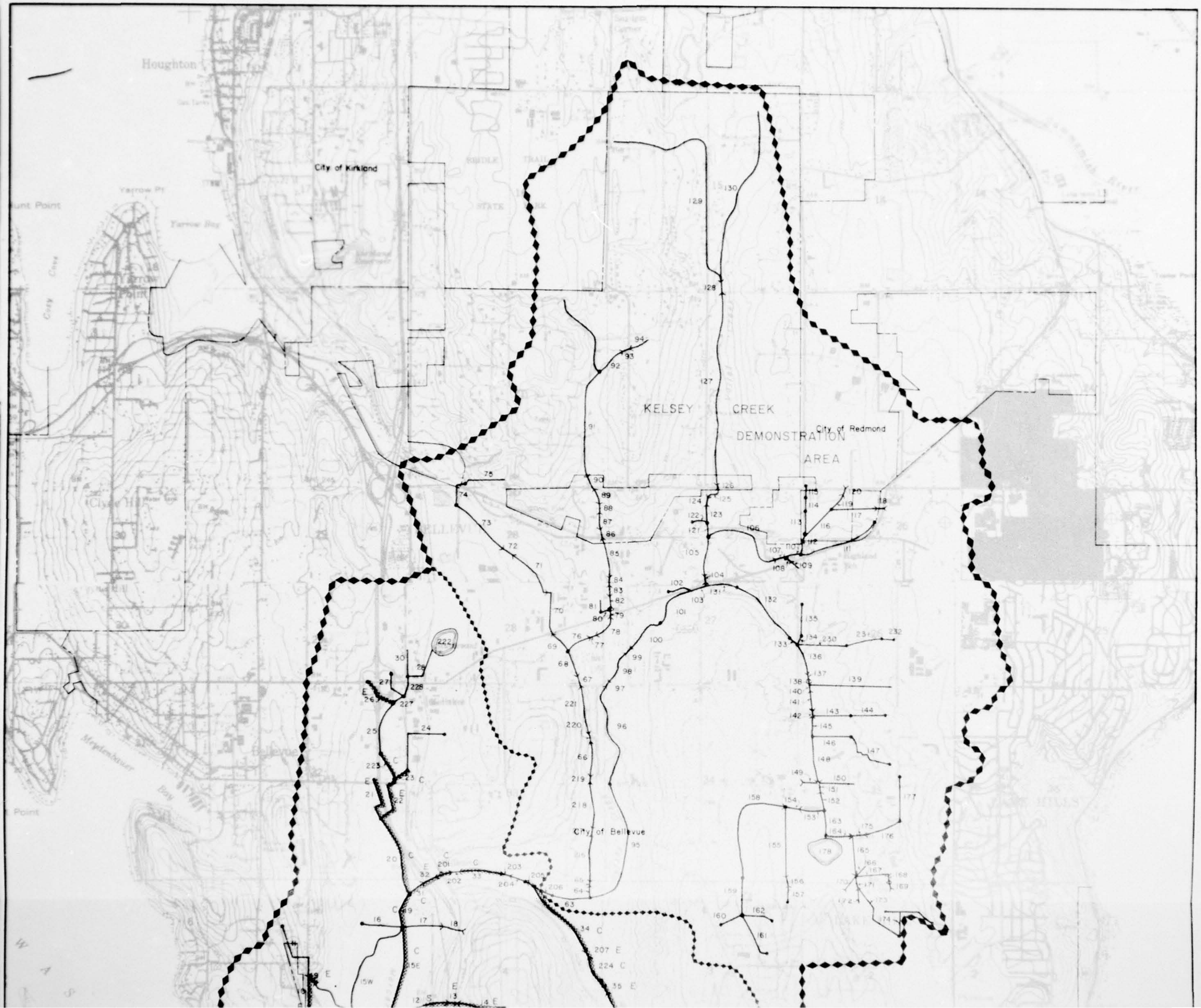
The Estimated Capital Cost for each element includes Contractor profit, engineering, legal and contingencies. In addition, land purchase and severance costs are included where land is required. All costs are based upon June 1973 prices.

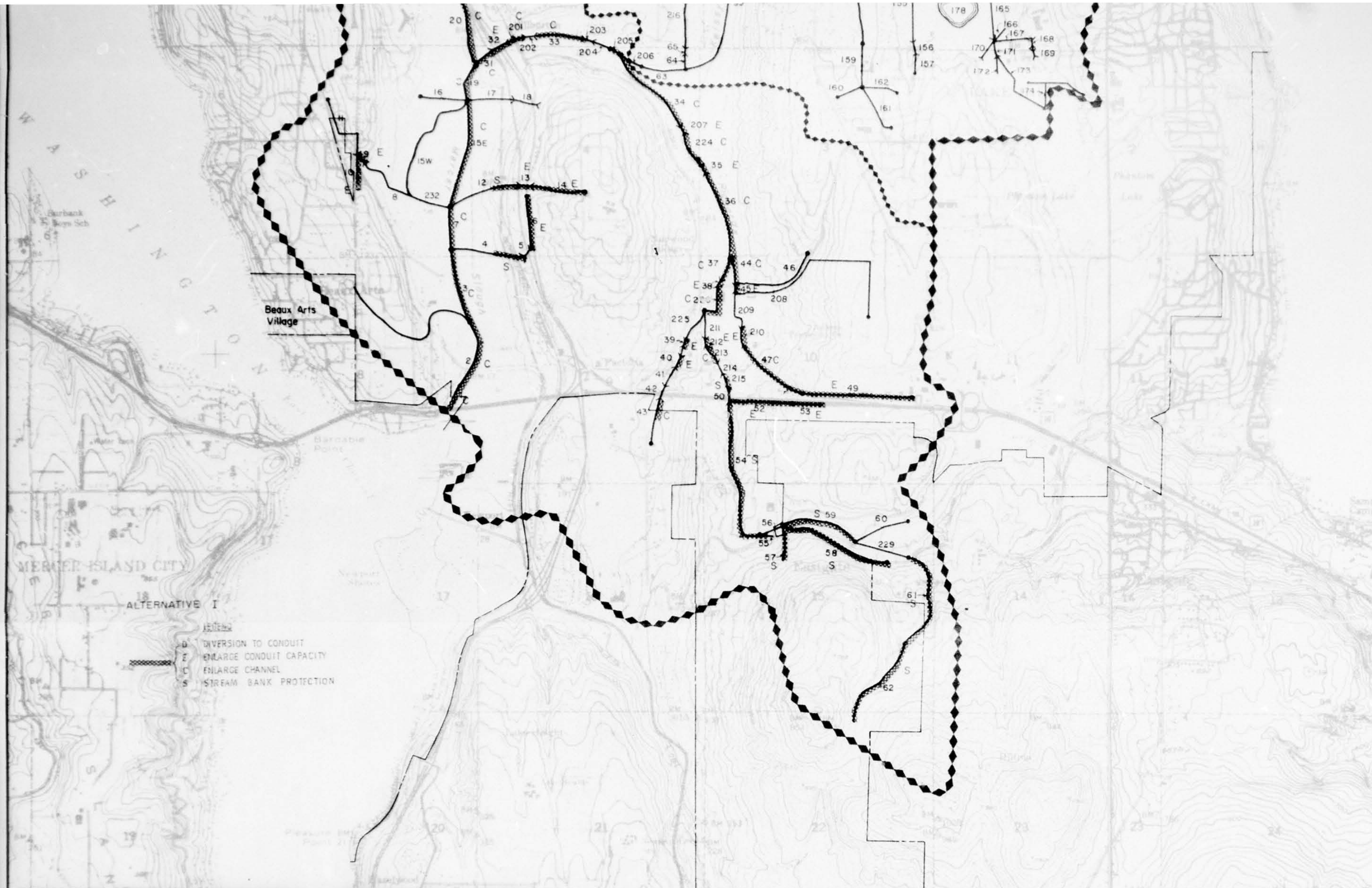
Total Estimated Capital Cost: $726,000
Round To: $700,000


KELSEY CREEK DEMONSTRATION AREA
City of Redmond
City of Bellevue
City of Kirkland
Houghton
Yarrow Pt
Yarrow Bay
Cozy Cove
Meydenbauer Bay



Beaux Arts Village
MERCER ISLAND CITY
WASHINGTON
PRESENT AND ANTICIPATED FUTURE PROBLEM AREAS
FLOODING
EROSION OR SEDIMENTATION
LEGEND
SUB-BASIN BOUNDARY
EXISTING CHANNEL
EXISTING CONDUIT
MANHOLE, INLET, OR JUNCTION
CHANNEL OR CONDUIT DESIG.
CITY LIMITS
COUNTY (METRO) BOUNDARY
LEVEE
CULVERT
HOLDING POND OR LAKE
N
MILES
FEET
NO
DESCRIPTION
DATE
APPROVED
REVISIONS
URBAN RUNOFF AND BASIN DRAINAGE STUDY
MERCER SLOUGH
PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL
KRAMER, CHIN AND MAYO, INC.
WATER RESOURCES ENGINEERS, INC.
YODER, TROTTER, ORLOB & ASSOCIATES
U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON
DATE AUGUST, 1974
FILE NO. E-26-1-161
SHEET 1B OF 1


KELSEY CREEK
DEMONSTRATION
AREA
City of Redmond
City of Kirkland
City of Bellevue
Houghton
Yarrow Pt
Yarrow Bay
BRIDLE TRAILS STATE PARK



LEGEND

SUB-BASIN BOUNDARY
EXISTING CHANNEL
EXISTING CONDUIT
MANHOLE, INLET, OR JUNCTION
CHANNEL OR CONDUIT DESIG. 5
CITY LIMITS
COUNTY (METRO) BOUNDARY
LEVEE

CULVERT
HOLDING POND OR LAKE

N

1/2 1/4 0 1
MILES

1000 500 0 4000
FEET

NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

MERCER SLOUGH

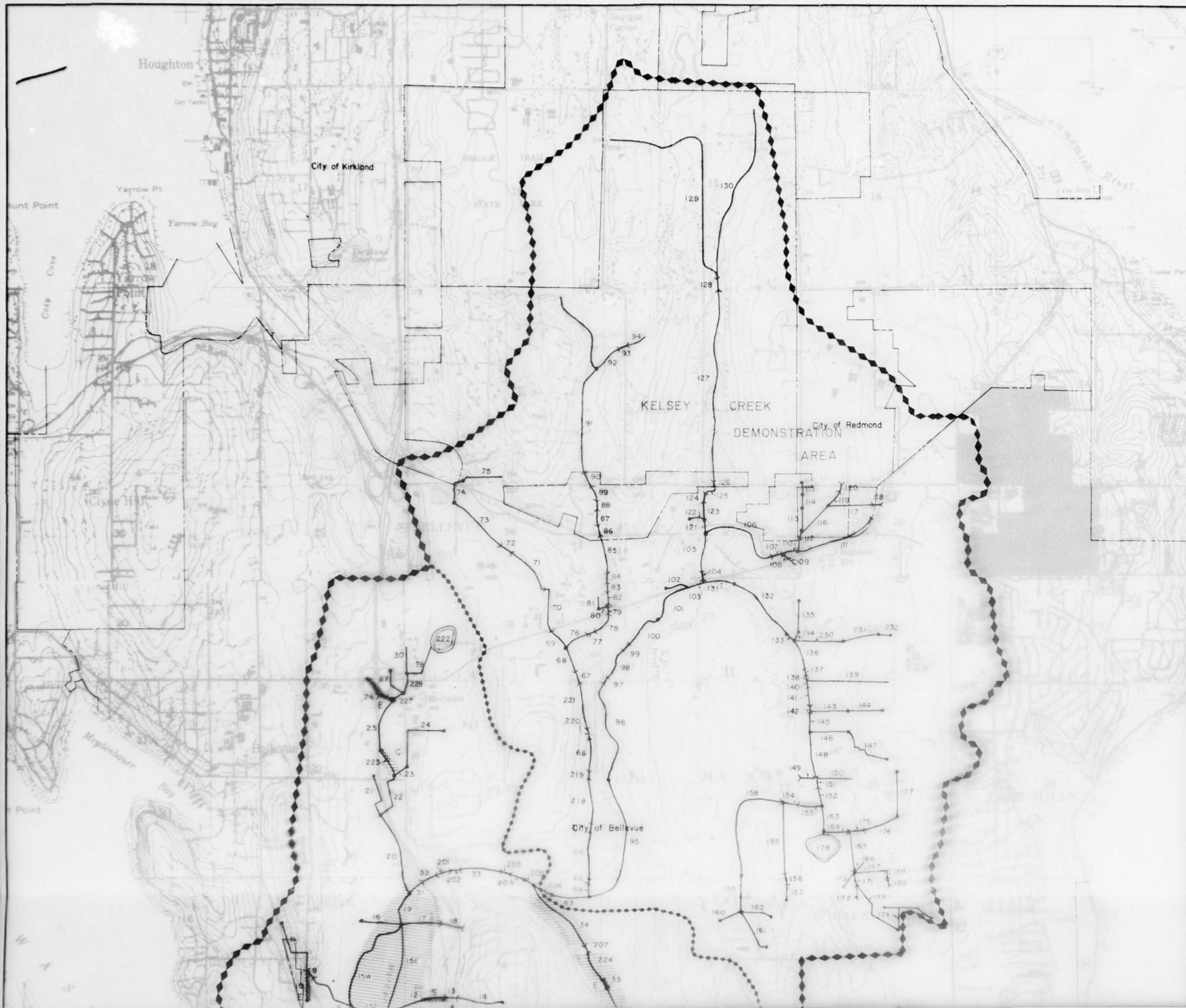
PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

KRAMER, CHIN AND MAYO, INC
WATER RESOURCES ENGINEERS, INC
YODER, TROTTER, ORLOB & ASSOCIATES

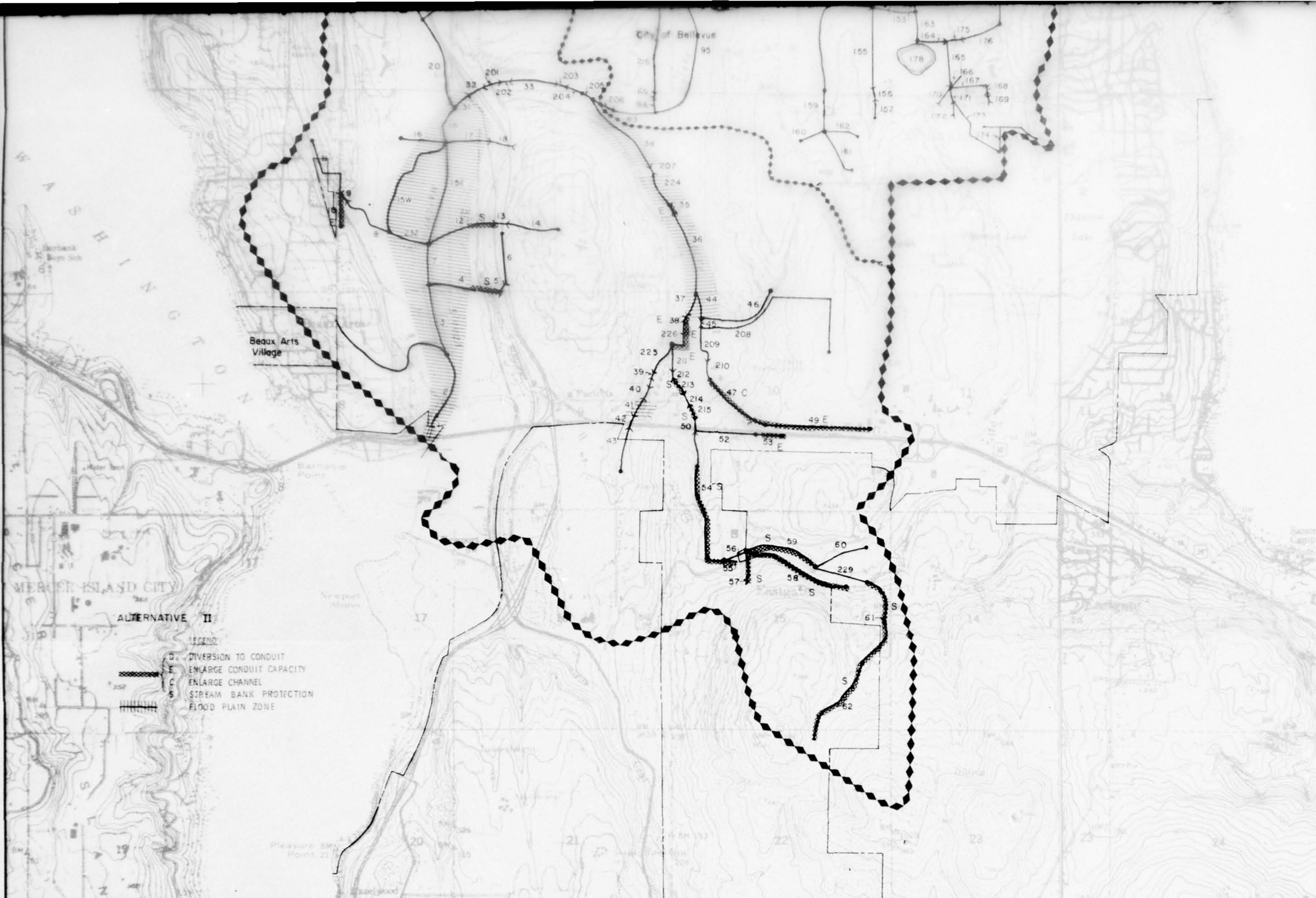
U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO E-26-1-161 SHEET 1b OF 1

2



KELSEY CREEK
DEMONSTRATION
AREA
City of Redmond
City of Kirkland
City of Bellevue
Houghton
Yarrow Pt
Yarrow Bay
Cozy Cove
Meydenbauer Bay



LEGEND

SUB-BASIN BOUNDARY
EXISTING CHANNEL
EXISTING CONDUIT
MANHOLE, INLET, OR JUNCTION
CHANNEL OR CONDUIT DESIG. 5
CITY LIMITS
COUNTY (METRO) BOUNDARY
LEVEE

CULVERT
HOLDING POND OR LAKE

N

1/2 1/4 0 1
MILES
1000 500 0 4000
FEET

NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

MERCER SLOUGH

PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

KRAMER, CHIN AND MAYO, INC
WATER RESOURCES ENGINEERS, INC
YODER, TROTTER, ORLOB & ASSOCIATES

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO E-26-1-161 SHEET 1c OF 1

REGIONAL SUB-BASIN C-15

COAL CREEK

GENERAL DESCRIPTION

The Coal Creek Sub-Basin is located south of Interstate Highway 90 in an urbanizing area south-easterly of Mercer Island, across the east channel of Lake Washington. It lies generally in a southeast/northwest orientation with Coal Creek flowing north and west to its point of discharge at Newport Shores on Lake Washington. The City of Bellevue has jurisdiction over approximately 10% of the sub-basin and King County has the remainder.

The sub-basin is characterized by three, distinct land-form types, those being: 1) the steep hill and ravine areas of the upper sub-basin that make up approximately two-thirds of the total land area, 2) the moderate midlands of the Newport Hills/Lake Boren area in the southwest portion of the sub-basin, and 3) the flat delta area of Newport Shores at Lake Washington. Total elevation change in the sub-basin is from 1600 feet to the 15 foot level of Lake Washington, over a distance of approximately six miles.

The principal stream in the sub-basin is Coal Creek, so named because of early-day coal mining operations in the area. It is approximately six miles long and has several unnamed tributaries.

Streams	Category	Drainage Area	Discharge
Coal Creek	III	7.2 sq. mi.	Lake Washington (Newport Shores)

As of 1972, 68% of the sub-basin consisted of vacant, uncleared, second-growth stands of timber and a major regional park along the stream-course. Some single-family housing exists in the Newport Shores and Newport Hills areas in the western portion of the sub-basin. Due to relatively severe topography, most of the Coal Creek Sub-Basin has remained unurbanized. Interstate 405 traverses the sub-basin at the western extremity and a small industrial development exists north of Lake Boren.

PERCENT OF SUB-BASIN AREA IN SPECIFIED LAND USE

Land Use	Existing (1970-72)	P.S.G.C. Land Use Projection Comprehensive	P.S.G.C. Land Use Projection Corridor
Single Family	15	67	75
Multiple Family			
Commercial/Services		1	1
Government and Education		5	3
Industrial		2	2
Parks/Dedicated Open Space	12	10	10
Agriculture	5	5	4
Airports, Railyards, Freeways, Highways			
Unused Land	68	10	5
Water			
Total	100	100	100
Total Impervious Area	5	25	30

Future developmental trends, as projected by the PSGC year 2000 Comprehensive Plan, indicate that low-density residential development and attendant educational facilities will exist throughout most of the sub-basin, and that some area along the creek will remain as open space and agricultural acreage. This plan also envisions modest increases in industrial and commercial land use. This same general picture also is projected in the year 2000 Corridor Plan except that additional land along Coal Creek would be reserved as open space. Realization of either of these plans without additional control of development will severely impact Coal Creek by the additional runoff.

An attempt was made by the City of Seattle in 1971 to locate a solid-waste disposal site in the Coal Creek Sub-Basin. As a result of citizen objection to the proposal, as expressed at public hearings, a final decision regarding the proposal has been postponed until conclusions of the RIBCO Solid Waste Management Study can be taken into consideration. No other major land-use changes are under consideration at this time.

NATURE OF EXISTING DRAINAGE SYSTEM

Coal Creek is the existing drainage system for runoff in the sub-basin. The stream and its tributaries are fed in the developed areas by storm drains. A major trunk drain system in Newport Hills discharges into a tributary that joins Coal Creek in the vicinity of Interstate 405. Coal Creek, in its existing condition, supports the highest known level of aquatic fauna native to this region, including cutthroat trout and coho salmon. Because much of the stream course is undeveloped or publicly owned, it has a high potential as an urban greenway and recreational area.

DRAINAGE PROBLEMS

Major problems in the Coal Creek area consist primarily of sedimentation and erosion. This fact can be attributed to the unusually steep natural channel slope of Coal Creek that averages 3%. Fortunately, development consisting primarily of single-family residential use is located only in the far western area of the sub-basin (community of Newport Hills). Little development exists directly adjacent to the natural creek or in the upstream areas of the watershed.

As described in the table of existing and projected land uses, a significant increase in impervious area is projected for the Coal Creek sub-basin which is now a largely undeveloped woodland area. Development is expected to increase from an existing 5% to 25-30% impervious land surface in the year 2000.

The results of hydrologic analyses indicate no significant difference between the Comprehensive and Corridor Plans, therefore, the drainage alternatives presented herein are applicable to both plans.

No computer modeling was done for existing flows along the stream, and it was therefore necessary to formulate plans based upon projected problems with existing facilities being used under future land-use conditions.

BASIC ISSUES AND STATUS OF DRAINAGE PLANNING

Coal Creek has been the focus of study by the City of Bellevue for inclusion as a natural element in that City's newly created drainage utility system. Once the drainage utility becomes fully operational, it will charge users of the system on the basis of their contribution to the runoff problem as measured by area of impervious surface. Because Coal Creek lies within more than one jurisdiction, the City of Bellevue will need to enter into an inter-governmental agreement with King County to assure that the County is aiding in the control of runoff within its jurisdiction.

King County has a continuing program for acquiring land along the upper reaches of the stream for park purposes. This program should have a positive effect upon drainage management in that it should protect the upper reaches from encroachment by man-made structures.

King County Public Works Department, Hydraulics Division, and Bellevue Public Works staff representatives were involved in review during preparation of the two alternative runoff-control systems described below.

ALTERNATIVE PLANS FOR PROPOSED DRAINAGE CONTROL

The existing drainage system of Coal Creek Sub-Basin as described by local agencies was evaluated by computer simulation applying the region's 10-year storm to P.S.G.C. year 2000 land use. Drainage problems thus identified were analyzed and possible solutions provided in development of alternative plans for drainage control as described herein.

ALTERNATIVE PLAN I

General Concept

This concept only makes use of three general types of improvements; a major trunkline, a concrete-lined channel, and enlarged (or parallel) pipelines placed in already developed areas.

Major Features

From computer model results, using the year 2000 land use, it was found that major Coal Creek flooding occured where Coal Creek and the furthest upstream tributary that originated in Newport Hills meet. To alleviate flooding in the main stem of Coal Creek, a major trunkline would divert water from Coal Creek at this junction for discharge directly into Lake Washington. The trunk parallels the creek along the hillside for a short distance until intersecting Coal Creek Parkway and then parallels a road leading toward Lake Washington.

In the Newport Hills area, the existing drainage system would be supplemented with parallel pipelines. This also would be done for the developed area east of Newport High School.

In the downstream reach of Coal Creek, where the existing channel is naturally lined with grass, the sides and bottom would be lined with concrete so that the additional flow from future development could be accommodated without further excavating the channel.

Cost

The cost for this alternative is estimated to be $2,100,000.

ALTERNATIVE PLAN II

General Concept

This alternative would be identical to Alternative Plan I with two major exceptions. First, there would be no major trunklines, and second, there would be runoff control.

Major Features

The most significant feature of this alternative is that of runoff control. Essentially, development is structured in the area so that runoff from property is limited to approximately the same runoff that would occur under present conditions. King County has a storm-drainage policy for plats and PUD's that states, "... drainage plans shall provide storm-water retention facilities so that peak discharge from the site will not be increased by more than 25% due to the proposed development."

Even with this runoff control, an increase in existing pipeline capacity in the Newport Hills area and the lining of the downstream Coal Creek channel would be required to prevent flooding.

Cost

The cost for this alternative is estimated to be $700,000.

PEAK FLOW COMPARISONS

The following table indicates 10-year peak flows under existing facilities and under alternative drainage management solutions for the year 2000.

COMPARISON OF 10-YEAR PEAK FLOWS
(Cubic Feet Per Second)

Location	Existing Facilities	Alternative Plan I	Alternative Plan II
End of 170th Avenue	120	120	50
Crossing of Newcastle Rd.	330	350	160
142nd Avenue South	710	750	300
Newport Hills School	740	750	380
I-405	560	820	440
Mouth	530	920	530

ENVIRONMENTAL ASSESSMENT OF ALTERNATIVE PLANS

As part of the process of developing system proposals for the various regional sub-basins in the RIBCO study, field inspections were made in each sub-basin for the purpose of evaluating suggested alternatives. The inspections were made based on the alternative evaluation procedure which identified 34 unique criteria under the general categories of 1) Effectiveness, 2) Human Values, 3) Environmental Factors, 4) Implementation, and 5) Resource Requirements. In addition, projected land use was reviewed and considered for compatability with the proposed systems. As applied to Coal Creek, the rating total for Alternative Plan I was a plus 16 on a scale ranging from plus 108 to negative 108. The overall rating of Alternative Plan II, which employed runoff control and stream protection in the lower reaches, was a plus 63. Both alternatives allow the stream to remain in its natural condition except at the lower end where it goes through the delta lands of Newport Shores.

Both alternatives are judged adequate in terms of effectiveness and both provide approximately the same level of human values. It is believed that the environmental effects of Alternative I upon the natural systems would be most detrimental because it does not provide land use or runoff controls. Both alternatives should provide adequate fish habitats. Implementation of Alternative Plan I might be more difficult, and much more costly, and would need greater cooperation between jurisdictions for construction of the major diversion trunk system. Resource requirements of both alternatives are comparatively small and have not influenced the overall rating dramatically.

There are three critical problem areas within the Coal Creek Sub-Basin. Two of the three need corrective measures regardless of the alternatives selected. They are: the natural stream below Newport Hills and the delta area of Coal Creek itself. The third critical area is the major portion of Coal Creek that runs through the upland streamway. It is generally believed that this area, either because of prior acquisition for park development or steep slopes directly adjacent to the stream, will be protected from damage resulting from encroachment.

CONCLUSIONS

Alternative Plan II is judged to be more effective in the overall management of storm drainage. It accomplishes whatever groundwater recharge is possible in this sub-basin as well as protecting water quality and does both with significantly less capital expense than would be necessary to implement Alternative Plan I. Alternative Plan II does require fairly immediate action, however. The more development that is allowed to occur without adequate runoff controls, the more aggravated the problems become. Because of the steep terrain and natural characteristics of the existing stream, both alternatives could be better judged if development patterns, as projected by existing land use plans and zoning were critically re-examined. Alternative Plan II also is con-

sidered to be consistent with the goals of the Bellevue Drainage Utility. Because of the extent of the sub-basin that lies within King County jurisdiction, that agency should have the lead role.

RUNOFF QUALITY SUMMARY
COAL CREEK

BASED UPON A 10-YEAR STORM PRECEDED BY 15 DAYS WITH LITTLE OR NO RAINFALL#

LOCATION	ALTERNATIVE PLAN	PEAK FLOW (cfs)	CONCENTRATION AT PEAK FLOW*				
			BOD	TOTAL COLIFORM	NH_3	$NO_2 + NO_3$	PO_4
Mouth of Creek	I	920	7	1.5×10^5	.1	.5	.1
	II	530	7	1.5×10^5	.1	.5	.1

Less than a total of 0.5 inches of rainfall in any one day.
* Concentrations in mg/liter except total coliform which is in MPN/100 ml.

EVALUATION MATRIX

COAL CREEK

ALTERNATIVES	SUB TOTAL	EFFECTIVENESS: Use of existing facilities	System reliability	System maintainability	System flexibility	Flood damage reduction	Consequences of overcharge	Erosion and sedimentation control	Cost/benefits ranking	SUB TOTAL	HUMAN VALUES: Urban quality (aesthetics)	Effect on land use	Displacement of people	Educational value	Community cohesion	Multiple use potential	Public health and safety	SUB TOTAL	ENVIRONMENTAL FACTORS: High flow conditions	Alteration of natural system	Effects on groundwater	Low flow conditions	Water quality	Construction disruption	Effects on wildlife	Effects on aquatic life	Effects on vegetation	SUB TOTAL	IMPLEMENTATION: Legislative requirements	Jurisdictional	Land acquisition	Public acceptance	Financing	Effects of no action	SUB TOTAL	RESOURCE REQUIREMENTS: Energy	Materials	Land	Capital	RATING TOTAL
		CRITERIA WEIGHT 1	4	3	2	4	4	4	2		CRITERIA WEIGHT 4	2	2	1	3	3	4		CRITERIA WEIGHT 4	4	4	4	4	2	4	4	4		CRITERIA WEIGHT 4	4	2	4	4	3		CRITERIA WEIGHT 3	3	2	2	
I	+10									+7								+7										-5							-3					+16
II	+16									+7								+27										+11							+2					+63

RIBCC URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative I Sub Basin Coal Creek

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
1	Channel	20'	2,500'	1.5:1	4'	Channel	Line existing channel with concrete	$202,000
3	Channel	20'	300'	1.5:1	4'	Channel	Line existing channel with concrete	$24,000
4	Culvert	7'	300'	0	6'	Parallel Pipe	66"	$41,000
36	Pipe	36"	300'			Parallel Pipe	24"	$14,000
6	Pipe	36"	400'			Parallel Pipe	24"	$19,000
7	Pipe	30"	1,100'			Parallel Pipe	24"	$52,000
8	Pipe	24"	1,600'			Parallel Pipe	24"	$75,000
9	Pipe	18"	900'			Parallel Pipe	24"	$42,000
10	Pipe	18"	800'			Parallel Pipe	24"	$38,000
37	Pipe	18"	1,600'			Parallel Pipe	24"	$75,000
14	Pipe	24"	500'			Parallel Pipe	36"	$33,000
16	Pipe	18"	1,500'			Parallel Pipe	24"	$71,000
100		None existing				Pipe	84" 4,000'	$724,000
101		None existing				Pipe	60" 6,000'	$720,000
100		None existing				Inlet	84" Diversion inlet for creek to pipe	$7,000

The Estimated Capital Cost for each element includes Contractor profit, engineering, legal and contingencies. In addition, land purchase and severance costs are included where land is required. All costs are based upon June 1973 prices.

Total Estimated Capital Cost: $2,137,000
Round To: $2,100,000

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative II Sub-Basin Coal Creek

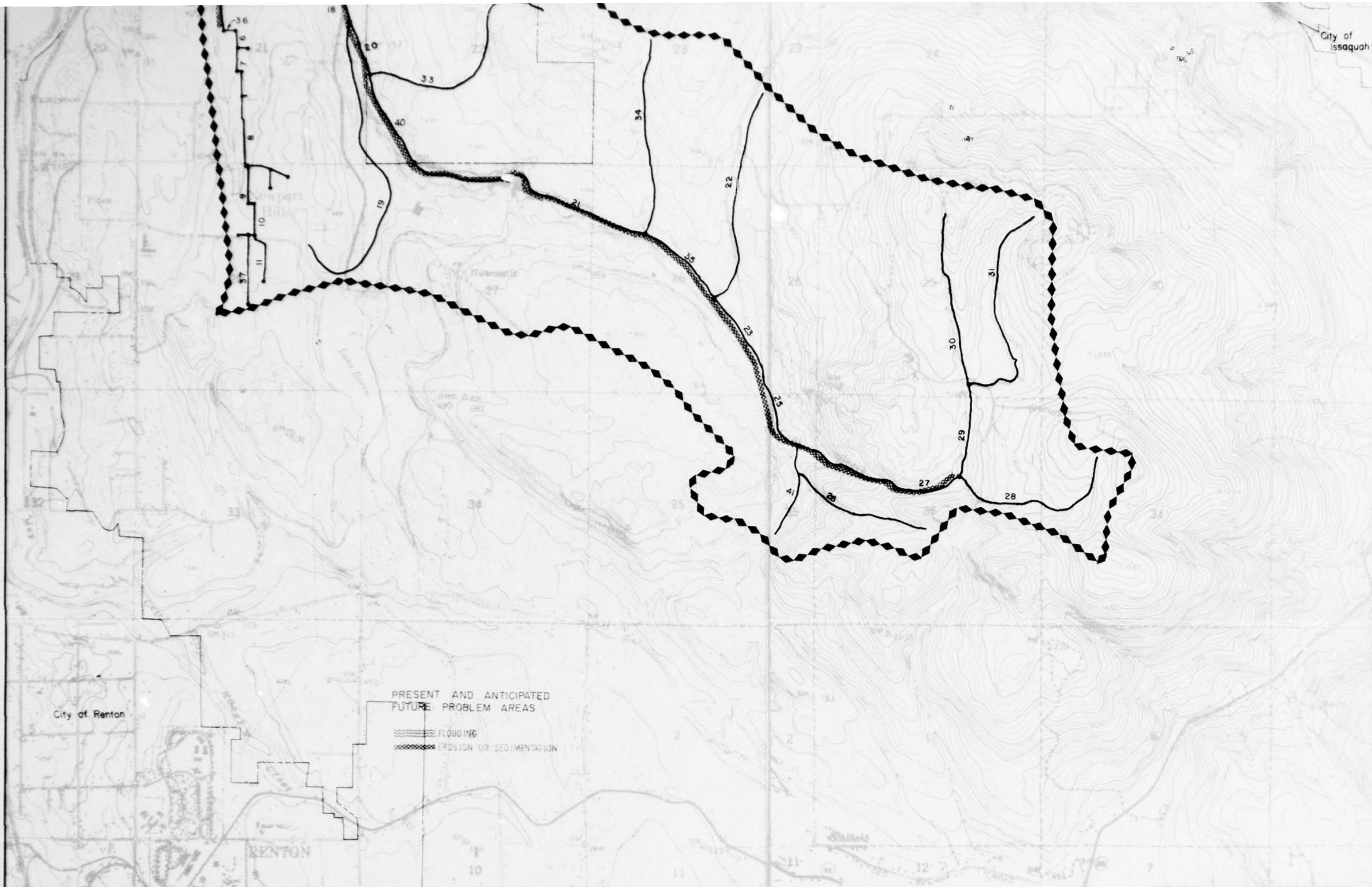
ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
1	Channel	20'	2,500'	1.5:1	4'	Channel	Line existing channel with concrete	$202,000
3	Channel	20'	300'	1.5:1	4'	Channel	Line existing channel with concrete	$24,000
4	Culvert	7'	300'	0	6'	Parallel Pipe	66"	$41,000
36	Pipe	36"	300'			Parallel Pipe	24"	$14,000
6	Pipe	36"	400'			Parallel Pipe	24"	$19,000
7	Pipe	30"	1,100'			Parallel Pipe	24"	$52,000
8	Pipe	24"	1,600'			Parallel Pipe	24"	$75,000
9	Pipe	18"	900'			Parallel Pipe	24"	$42,000
10	Pipe	18"	800'			Parallel Pipe	24"	$38,000
37	Pipe	18"	1,600'			Parallel Pipe	24"	$75,000
14	Pipe	24"	500'			Parallel Pipe	36"	$33,000
16	Pipe	18"	1,500'			Parallel Pipe	24"	$71,000

The Estimated Capital Cost for each element includes Contractor profit, engineering, legal and contingencies. In addition, land purchase and severance costs are included where land is required. All costs are based upon June 1973 prices.

Total Estimated Capital Cost: $686,000

Round To: $700,000

City of Issaquah
SAMMAMISH LAKE
City of Bellevue



LEGEND

SUB-BASIN BOUNDARY
EXISTING CHANNEL
EXISTING CONDUIT
MANHOLE, INLET, OR JUNCTION
CHANNEL OR CONDUIT DESIG. 5
CITY LIMITS
COUNTY (METRO) BOUNDARY
LEVEE

CULVERT
HOLDING POND OR LAKE

N

MILES: 1/2 1/4 0 1
FEET: 1000 500 0 4000

NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

COAL CREEK

PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

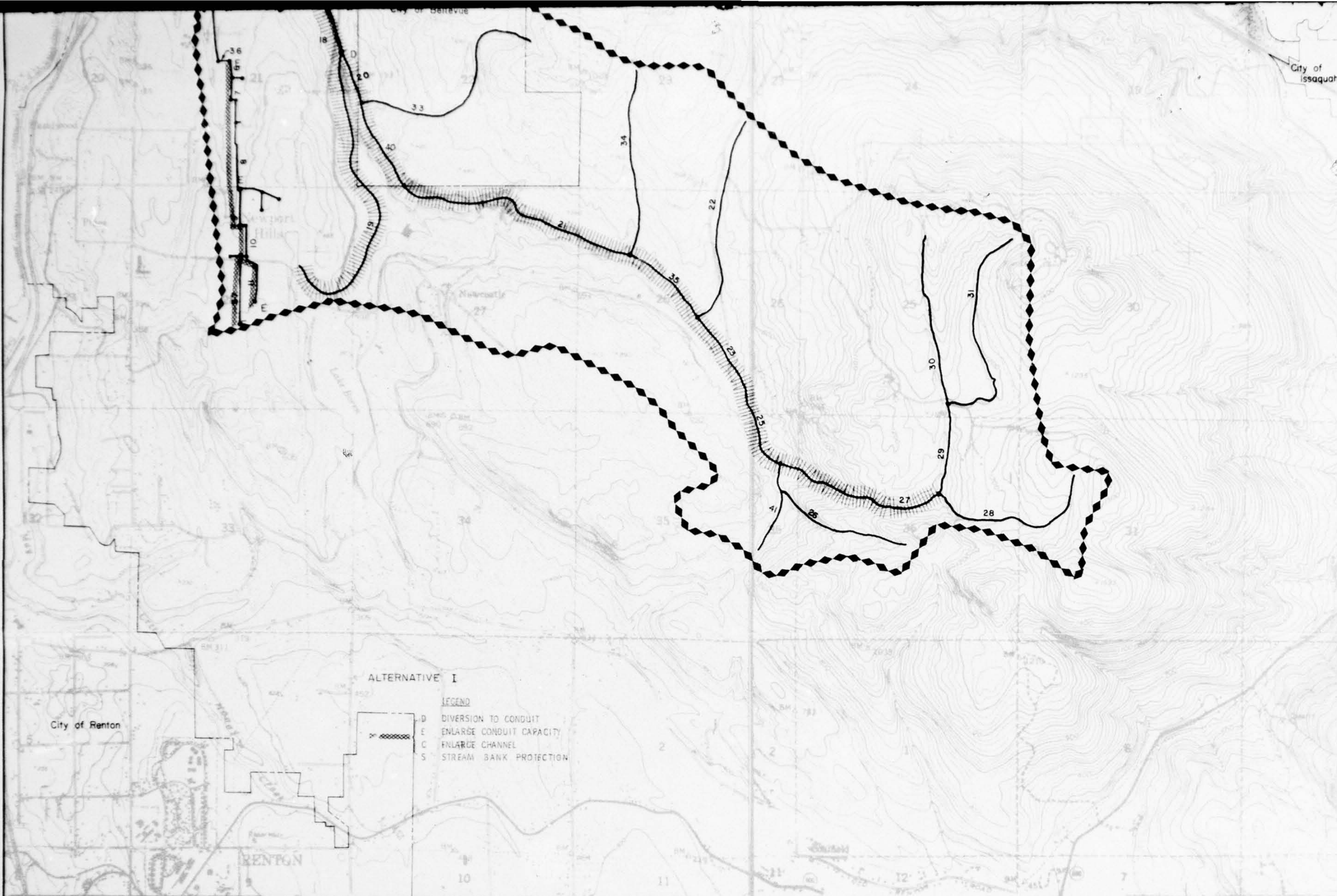
KRAMER, CHIN AND MAYO, INC
WATER RESOURCES ENGINEERS, INC
YODER, TROTTER, ORLOB & ASSOCIATES

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO. E-26-1-161 SHEET 10 OF 1

2


City of Issaquah
SAMMAMISH LAKE
City of Bellevue
Mercer
Slough



LEGEND

SUB-BASIN BOUNDARY
EXISTING CHANNEL
EXISTING CONDUIT
MANHOLE, INLET, OR JUNCTION
CHANNEL OR CONDUIT DESIG. 5
CITY LIMITS
COUNTY (METRO) BOUNDARY
LEVEE
CULVERT
HOLDING POND OR LAKE

1/2 1/4 0 1
MILES
1000 500 0 4000
FEET

NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

COAL CREEK

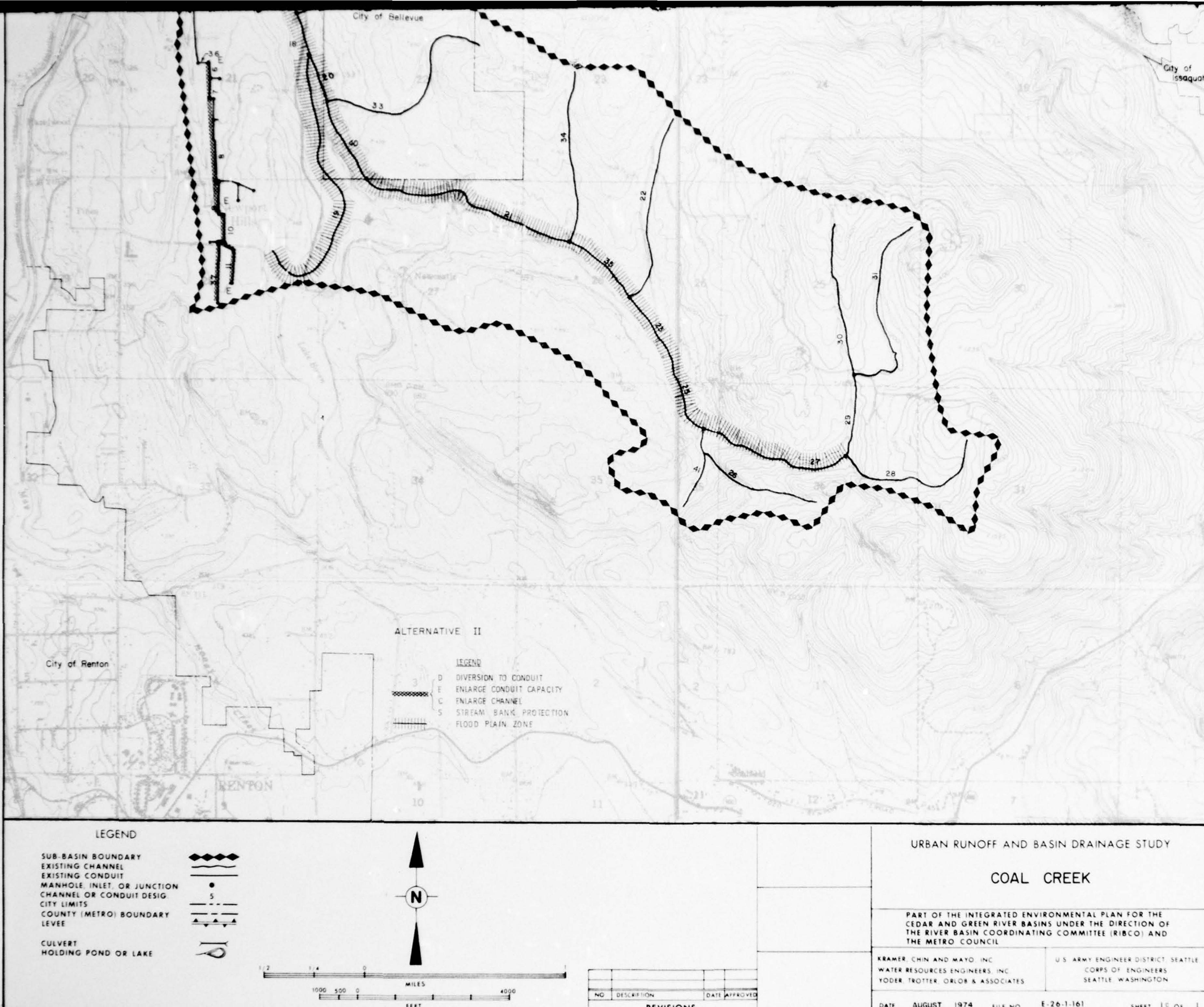
PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

KRAMER, CHIN AND MAYO, INC
WATER RESOURCES ENGINEERS, INC
YODER, TROTTER, ORLOB & ASSOCIATES

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO E-26-1-161 SHEET 1b OF 1

City of Issaquah
S A M M A M I S H   L A K E
City of Bellevue



NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

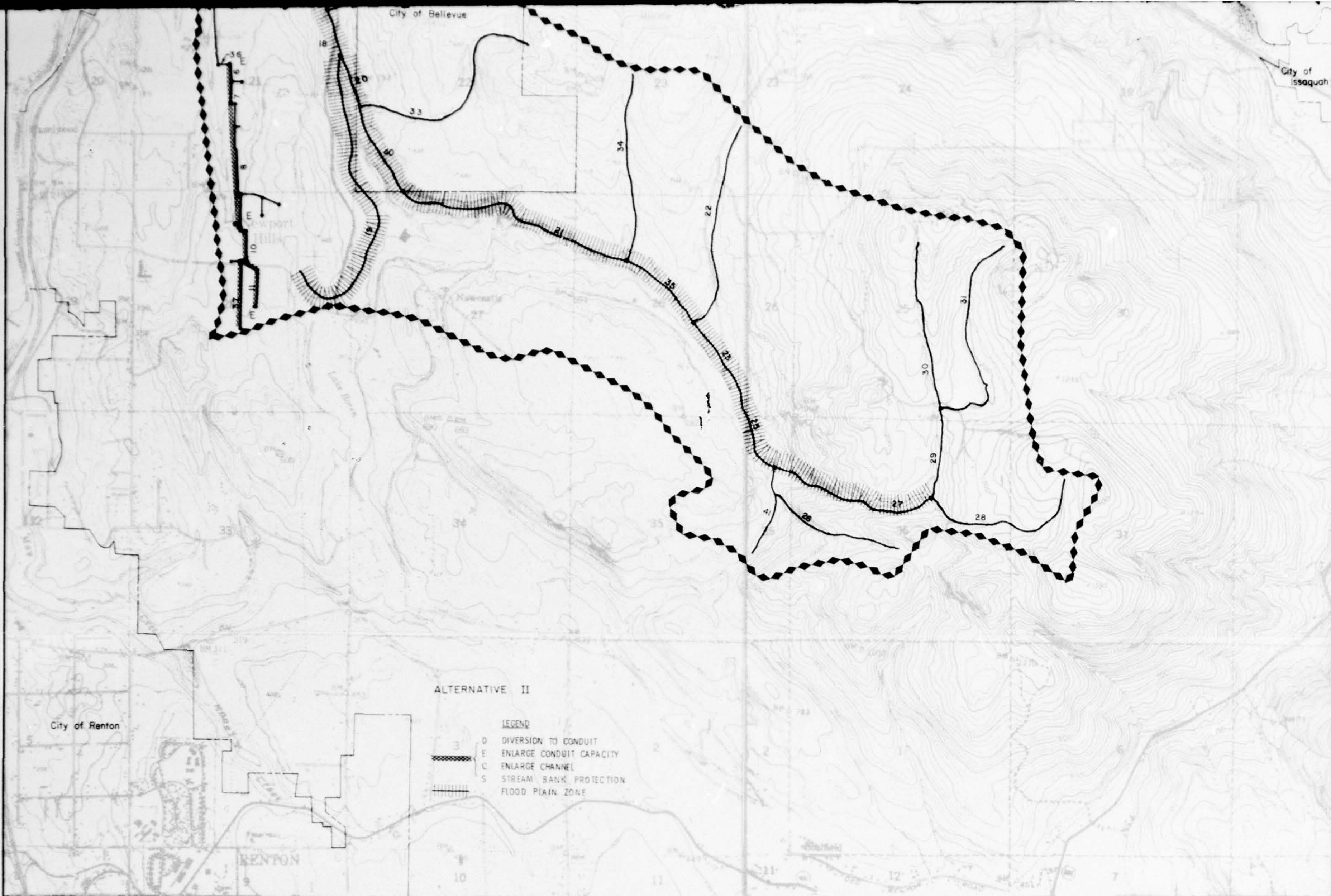
COAL CREEK

PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

KRAMER, CHIN AND MAYO, INC
WATER RESOURCES ENGINEERS, INC
YODER, TROTTER, ORLOB & ASSOCIATES

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO E-26-1-161 SHEET 1C OF 1



LEGEND

SUB-BASIN BOUNDARY
EXISTING CHANNEL
EXISTING CONDUIT
MANHOLE, INLET, OR JUNCTION
CHANNEL OR CONDUIT DESIG.
CITY LIMITS
COUNTY (METRO) BOUNDARY
LEVEE
CULVERT
HOLDING POND OR LAKE

N

MILES 1/2 1/4 0 1
FEET 1000 500 0 4000

NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

COAL CREEK

PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

KRAMER, CHIN AND MAYO, INC
WATER RESOURCES ENGINEERS, INC
YODER, TROTTER, ORLOB & ASSOCIATES

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO E-26-1-161 SHEET 1C OF 1

2

REGIONAL SUB-BASIN C-17

LAKE WASHINGTON EAST

GENERAL DESCRIPTION

The Lake Washington East Sub-Basin consists of Mercer Island and those areas along the east and south shores of the lake that drain directly to the lake without forming major rivers or creeks. The sub-basin is replete with smaller streams that can cause serious drainage problems as urbanization takes place.

Three of the more salient hydrologic features of the sub-basin are Yarrow Slough between Kirkland and Yarrow Point, Juanita Slough north of Kirkland, and Luther Burbank Park on the north end of Mercer Island. These areas comprise the only major marshes remaining along the shores of Lake Washington. As the sub-basin was developed, much of the lakeshore marsh land was filled and built upon.

Present development in the sub-basin varies from rural, natural areas in Kirkland and Bellevue to the industrial sections of Renton. The largest single land use in the sub-basin is residential. Much of the island and east shore areas are prime residential suburbs for Seattle commuters.

PERCENT OF SUB-BASIN AREA IN SPECIFIED LAND USE

Land Use	Existing (1970-72)	P.S.G.C. Land Use Projection	
		Comprehensive	Corridor
Single Family	78	73	74
Multiple Family	1	5	4
Commercial/Services	3	5	5
Govt. and Educ.	1	1	1
Industrial	1	5	5
Parks/Dedicated Open Space	5	5	5
Agriculture			
Airports, Railyards, Freeways, Highways	1	1	1
Unused Land	10	5	5

Land Use	Existing (1970-72)	P.S.G.C. Land Use Projection Comprehensive	Corridor
Water			
Total	100	100	100
Total Impervious Area	25	35	35

NATURE OF EXISTING DRAINAGE SYSTEM

Drainage facilities in the sub-basin vary substantially, but generally consists of conventional storm-drainage systems in developed areas that drain to small streams or directly to Lake Washington. In the unincorporated portions of the sub-basin, storm drainage is conveyed mainly by roadside ditches and natural watercourses; few storm-drain systems have been installed.

Kirkland has a fairly extensive storm-drain system with few remaining streams. The communities of Yarrow Point, Clyde Hills, Hunts Point and Medina all have storm-drain systems with varying proportions of roadside ditches. Detention ponds are used for runoff control in Medina. The portions of Bellevue and Renton in the sub-basin and Beaux Arts have drainage systems that utilize mainly roadside ditches and culverts. Storm water on Mercer Island is conveyed in closed conduits through most developed upland areas, but roadside ditches are used significantly, and most storm runoff enters Lake Washington through natural creeks and streams.

The streams that still exist in the sub-basin generally were assets that attracted original development, but they are now subject to flooding, erosion and siltation problems as runoff rates from upland areas increase with development.

DRAINAGE PROBLEMS

Because this sub-basin is composed of many discrete sub-areas, drainage problems and their solutions can be approached on an individual basis and closely tied planning is not as important as in other sub-basins in the RIBCO Study Area.

Major drainage problems in the sub-basin can be divided into six different areas: Forbes Lake/Juanita Slough, downtown Kirkland, Yarrow Slough, Mercer Island, northeast Renton, and north Bellevue. There are many additional minor drainage problems in the sub-basin, but they are solvable by improved maintenance or local improvements.

The creek connecting Forbes Lake to Juanita Slough has experienced significant flooding and erosion problems because of development adjacent to the creek and increased flow rates brought about by up-

stream urbanization. More industrial development is planned along the creek and drainage problems will worsen without effective planning. In addition to flooding of structures and aesthetic effects of erosion, increased runoff rates also can harm wildlife in the slough.

Most runoff in downtown Kirkland is conveyed by closed conduit systems. The major system along Central Way has experienced some surcharging since the construction of Interstate 405, and with more industrial and multi-family residential development planned for the area, flooding conditions will worsen.

The stream entering Yarrow Slough from the east will be subject to increased flooding and erosion if the sub-basins continue to develop as planned (multi-family residential and industrial). If the stream capacity is increased to carry higher runoff rates, the effects upon the lower portions through Yarrow Slough will be detrimental to wildlife habitat.

Drainage problems on Mercer Island have been recognized by the City for several years and a detailed comprehensive plan has been prepared. Generally, the problems consist of erosion and flooding along the numerous streams entering Lake Washington. These problems usually have been the result of increased runoff rates brought about by extensive upland development. Those problems shown on the problem area map include some of the more major problems on the Island.

Drainage problems in northeast Renton are mainly the result of extensive sub-basin development and an undersize storm drain system.

In addition, there are several storm drains in north Bellevue which will experience surcharge and natural watercourses downstream that will not carry increased flows adequately.

Both the 2000 Comprehensive and Corridor land use plans indicate a further urbanization of the Lake Washington East sub-basin. Existing drainage problems will become severe because of increases in impervious areas and faster runoff. The total impervious area in this sub-basin with either land use projection will increase from the existing 25% level to approximately 35% as shown by the table of projected land uses.

The results of hydrologic analysis indicate no significant difference between the Comprehensive and Corridor Plans. Therefore, the drainage alternatives presented herein are applicable to both plans.

BASIC ISSUES AND STATUS OF DRAINAGE PLANNING

No sub-basin-wide storm-water management planning has been completed. Individual jurisdictions have prepared extensive drainage plans. Mercer Island recently completed revisions to its comprehensive

drainage plan that include provisions for runoff control, stream preservation and mitigation of flooding problems. Bellevue is in the process of comprehensive storm-water management planning.

There has been increasing citizen interest in stream preservation in several portions of this sub-basin. A citizen's group has expressed interest in preserving Juanita Slough and Bellevue and Mercer Island citizens have indicated similar interest in many of the smaller streams there.

ALTERNATIVE PLANS FOR PROPOSED DRAINAGE CONTROL

The existing drainage system of the Lake Washington East Sub-Basin as described by local agencies, was evaluated by computer simulation that applied the region's 10-year storm to the year 2000 land use. Drainage problems thus identified were analyzed and possible solutions were provided in development of alternative plans for drainage control as described below.

Two major alternative plans were developed to provide solutions to the Lake Washington East drainage problems. The first consists of enlarging streams and conduits and providing diversions, and the second controls runoff rates and provides flood-plain zoning in addition to enlarging conduits and providing diversions. The description of these alternative plans follows.

ALTERNATIVE PLAN I

General Concept

This alternative consists of more structural or conventional approach to the problems of the sub-basin. No attempt is made to control runoff rates; instead, undersized systems are enlarged or flow is diverted to other conduits or channels.

Major Features

The major features of this alternative are channel enlargements and bank protection along the Juanita Slough and Yarrow Slough Creeks, enlargement of the Kirkland, Renton, and Bellevue storm drain systems, and installation of diversion storm drains on Mercer Island.

The improvements to the channels of creeks entering Juanita and Yarrow Sloughs consist of excavation and rock protection. The enlargement of the storm drain systems is accomplished by installation of parallel pipes in many systems. Improvements for Mercer Island consist mainly of new storm drain systems for diverting a portion of the runoff from streams that are subject to flooding and erosion.

Cost

The total capital cost of this alternative is estimated to be $2,700,000.

Channelization and uncontrolled development along the creeks draining to Juanita Slough and Yarrow Slough will increase maintenance requirements somewhat, but most of the other portions of the alternative will require routine storm-drain maintenance.

The Lake Washington East Sub-Basin consists of ten separate jurisdictions: The cities of Kirkland, Bellevue, Mercer Island, Renton, Medina, Beaux Arts, the towns of Hunts Point, Yarrow Point and Clyde Hill, and King County. However, coordination of all of these jurisdictions would not be required to achieve this alternative, because of the independence of each of the drainage systems flowing into Lake Washington. Past coordination between Clyde Hill, Hunts Point, and Yarrow Point should continue.

ALTERNATIVE PLAN II

General Concept

This alternative attempts to preserve the natural watercourses as much as possible by controlling runoff rates and not allowing structural encroachment upon the creeks.

Major Features

The major features of this alternative are runoff control from future development, utilization of Forbes Lake as a holding basin, flood-plain zoning along the creek entering Juanita and Yarrow Sloughs, and some holding basins and streambank improvements for Mercer Island. In Kirkland, Renton, Bellevue and portions of Mercer Island where development is already extensive, the use of enlarged storm drain systems is the only feasible solution, although their sizes are somewhat reduced by runoff control requirements.

Flood-plain zoning along the creeks entering Juanita and Yarrow Sloughs will obviate the need for extensive channel improvements. On-site control of runoff from future development, and the use of Forbes Lake as a storage facility, will maintain flows at low enough levels to reduce flooding. Even with control of runoff from future development, parallel storm drains will be necessary at several points in Kirkland, Bellevue, and Renton. Detention basins are used where possible on Mercer Island but diversion of storm water is still necessary in some basins.

Cost

The estimated capital cost of this alternative is $1,600,000.

Though the runoff control facilities of this alternative require additional maintenance, the overall maintenance requirements of this alternative are comparable to those of Alternative Plan I.

Achievement of this alternative again does not particularly require cooperation between the ten jurisdictions in the sub-basin because of the independence of the streams running into Lake Washington.

PEAK FLOW COMPARISON

The following table indicates 10-year peak flows with existing facilities and land use and with alternative drainage management solutions for the year 2000.

COMPARISON OF 10-YEAR PEAK FLOWS
(Cubic Feet Per Second)

Location	Existing Facilities	Alternative Plan I	Alternative Plan II
Juanita Slough	600	650	360
Kirkland Outfall	400	500	400
Yarrow Slough	450	600	250
Mercer Island Drainage Basin 21	40	50	50
Renton Outfall	300	550	475

ENVIRONMENTAL ASSESSMENT OF ALTERNATIVE PLANS

Field inspections were made to judge the applicability of the suggested alternative plans for this sub-basin. This procedure was followed throughout the RIBCO Study for development of alternative plans for the various regional sub-basins. The inspections were based upon the alternative evaluation procedure which identified 34 unique criteria grouped in general categories as follows: 1) Effectiveness, 2) Human Values, 3) Environmental Factors, 4) Implementation, and 5) Resource Requirements.

The various structural solutions were checked against the appropriate criteria and the various non-structural solutions were reviewed for their relationship to existing and probable future developments. The criteria rating for Alternative Plan I, which employs channelization, enlargement of conduits, and providing diversions, was a minus 15 out of a possible range from a positive total of 108 and a negative total of 108. The total evaluation rating for Alternative Plan II, which employs runoff control and flood plain zoning in addition to providing enlargement of

conduits and diversions, was a plus 12.

Both alternative plans were judged to be effective in controlling drainage. Both plans involved certain sacrifices of human value and human uses of the land once they are built. Environmentally, Alternative Plan II clearly offered more resource preservation than Alternative Plan I, which required channelization of the stream all the way to Yarrow Bay as well as a large portion of Juanita Slough. Neither alternative is part of present planning of any of the involved agencies. However, extensive cooperation between the ten separate agencies will not be required in most cases before the plans can be realized. Both of the alternative plans involved commitments of the use and management of natural resources because they rely upon certain structural treatments for all or part of their solutions. Therefore, neither alternative can be said to be clearly superior to the other in this concern.

The most critical element in these two alternatives is the use of flood-plain zoning and runoff control in Alternative Plan II to protect the natural character of Juanita and Yarrow Sloughs.

Since Alternative Plan II does rely upon flood-plain zoning and runoff control from future land development, this treatment combination if it is to be part of the chosen alternative, should be implemented as an early organized effort. Any portion of the sub-basin that develops without these combined controls will require more structural treatment than Alternative Plan II can accommodate. This issue should be brought to the attention of all citizens and their local agencies.

There also are other sacrifices that are involved in the two alternative plans. Alternative Plan I allows development within most of the pastoral flood plain, whereas Alternative Plan II requires that this area be flood-plain zoned thereby effectively removing it from any future intensive land uses typical of urbanized areas.

CONCLUSIONS

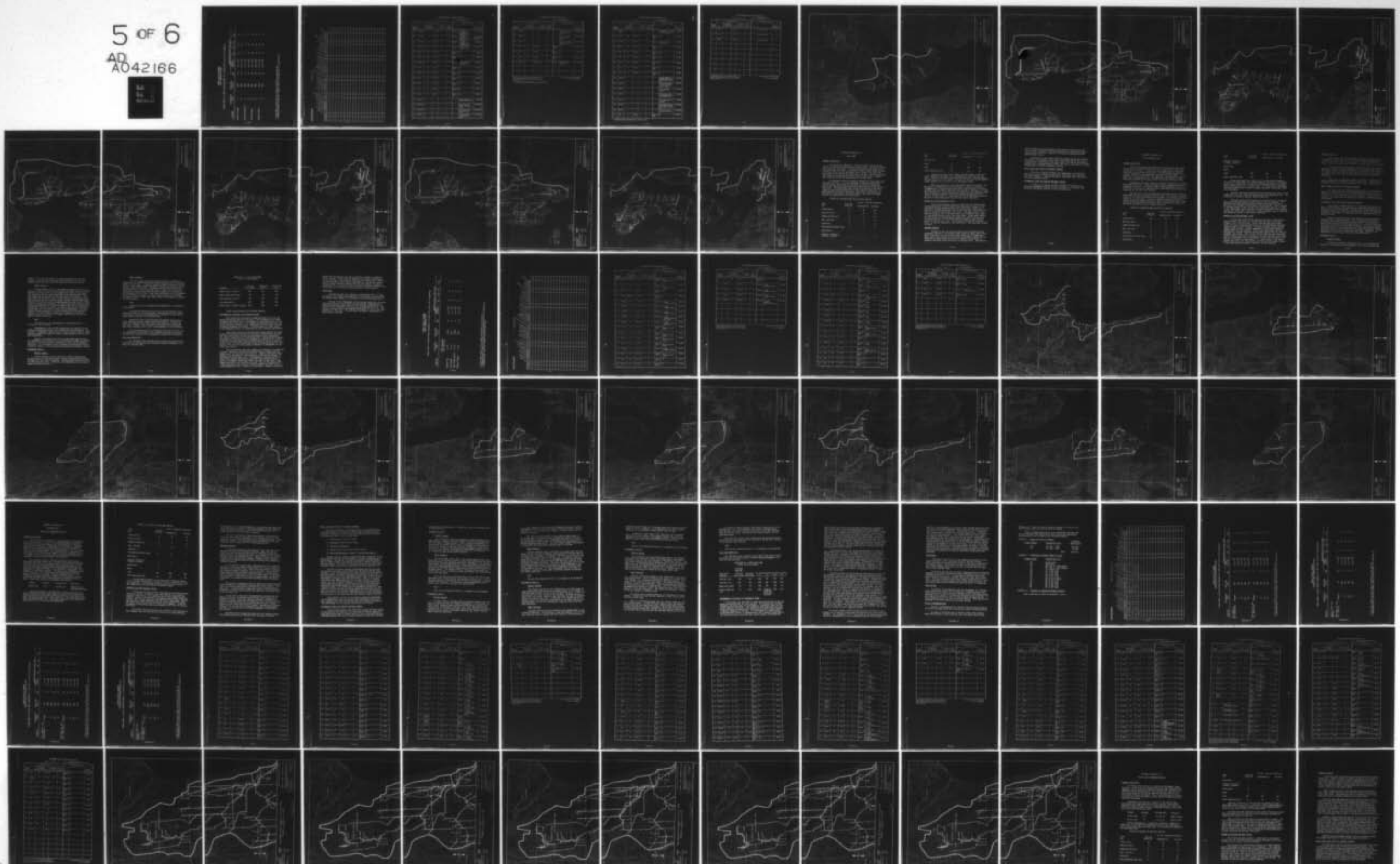
Alternative Plan II is clearly superior to Alternative Plan I because of the still relatively undeveloped nature of much of this sub-basin. However, it does require immediate action to protect and preserve the natural values. As pointed out above, this action would require runoff control at or near existing rates for any new development. It also requires designation of several areas, particularly along Yarrow and Juanita Sloughs, to be flood-plain zoned.

Each individual jurisdiction should proceed independently to form an effective master drainage plan incorporating the conditions of Alternative Plan II. All ten of these agencies should then move to implement and enforce the required runoff controls and flood-plain zoned within their own jurisdiction.

AD-A042 166 KCM-WRE/YTO SEATTLE WASH F/G 8/8
ENVIRONMENTAL PLANNING FOR THE METROPOLITAN AREA CEDAR-GREEN RI--ETC(U)
DEC 74 DACW67-73-C-0022

UNCLASSIFIED NL

5 OF 6
AD
A042166



RUNOFF QUALITY SUMMARY
LAKE WASHINGTON EAST

BASED UPON A 10-YEAR STORM PRECEDED BY 15 DAYS WITH LITTLE OR NO RAINFALL#

LOCATION	ALTERNATIVE PLAN	PEAK FLOW (cfs)	CONCENTRATION AT PEAK FLOW*				
			BOD	TOTAL COLIFORM	NH_3	$NO_2 + NO_3$	PO_4
Juanita Slough	I	650	15	6.2×10^5	.6	1.2	.3
	II	360	20	8.6×10^5	.9	1.6	.5
Kirkland Outfall	I	500	6	1.7×10^5	.1	.5	.2
	II	400	8	2.0×10^5	.2	.6	.2
Yarrow Slough	I	600	18	2.9×10^5	.6	1.2	.4
	II	250	29	3.8×10^5	.8	2.0	.6
Renton Outfall	I	550	15	6.2×10^5	.8	1.4	.4
	II	475	15	5.7×10^5	.7	1.4	.5

Less than a total of 0.5 inches of rainfall in any one day.
* Concentrations in mg/liter except total coliform which is in MPN/100 ml.

EVALUATION MATRIX

LAKE WASHINGTON EAST

		EFFECTIVENESS									HUMAN VALUES								ENVIRONMENTAL FACTORS										IMPLEMENTATION							RESOURCE REQUIREMENTS				RATING TOTAL
		Use of existing facilities	System reliability	System maintainability	System flexibility	Flood damage reduction	Consequences of overcharge	Erosion and sedimentation control	Cost/benefits ranking		Urban quality (aesthetics)	Effect on land use	Displacement of people	Educational value	Community cohesion	Multiple use potential	Public health and safety		High flow conditions	Alteration of natural system	Effects on groundwater	Low flow conditions	Water quality	Construction disruption	Effects on wildlife	Effects on aquatic life	Effects on vegetation		Legislative requirements	Jurisdictional	Land acquisition	Public acceptance	Financing	Effects of no action		Energy	Materials	Land	Capital	
ALTER-NATIVES	SUB TOTAL	CRITERIA WEIGHT 1	4	3	2	4	4	4	2	SUB TOTAL	CRITERIA WEIGHT 4	2	2	1	3	3	4	SUB TOTAL	CRITERIA WEIGHT 4	4	4	4	4	2	4	4	4	SUB TOTAL	CRITERIA WEIGHT 4	4	2	4	4	3	SUB TOTAL	CRITERIA WEIGHT 3	3	2	2	
I	+8									-1								-10										-4							-8					-15
II	+13									+5								+4										-4							-6					+12

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative I   Sub-Basin Lake Washington East

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
41	Channel	8'	6,500'	2:1	4'	Channel	10' width 2:1 side slopes 4' depth 2,000' streambank protection	$105,000
144	Channel	8'	4,500'	2:1	4'	Channel	10' width 2:1 side slopes 4' depth 1,000' streambank protection	$54,000 Land cost not included
57	Channel	8'	2,500'	2:1	4'	Channel	12' width 2:1 side slopes 4' depth 2,000' streambank protection	$100,000
55	Channel	10'	1,800'	2:1	4'	Channel	1,000' streambank protection	$46,000
29	Pipe	48"	1,200'			Parallel Pipe	36"	$79,000
31	Pipe	48"	200'			Parallel Pipe	27"	$9,000
87	Channel	8'	1,200'	2:1	4'	Channel	1,200' Streambank protection	$55,000
96	Pipe	48"	1,400'			Parallel Pipe	30"	$76,000
99	Pipe	42"	1,150'			Parallel Pipe	42"	$91,000
100	Pipe	24"	1,000'			Parallel Pipe	30"	$54,000
142	Pipe	15"	3,800'			Parallel Pipe	18"	$114,000
98	Pipe	15"	2,800'			Parallel Pipe	15"	$70,000
143	Pipe	15"	2,400'			Parallel Pipe	15"	$60,000
105	Channel						Enlarge capacity of concrete flume at lake	$6,000**
114	Channel						Divert from creek with 30" storm drain system	$340,000**
117	Channel						Divert from stream with storm drain system	$200,000**
161	Channel						Divert from stream with storm drain system	$195,000**

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative I Sub-Basin Lake Washington East

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
165	Channel						Divert from stream with storm drain system	$100,000**
170	Channel						Divert from stream with storm drain system	$155,000**
180	Channel						Install storm drain system to reduce ditch flooding	$240,000**
81	Pipe	12"	3,300'			Parallel Pipe	36"	$218,000
84	Pipe	42"	1,300'			Parallel Pipe	30"	$70,000
85	Pipe	36"	2,600'			Parallel Pipe	30"	$140,000
82	Channel	6'	1,800'	2:1	4'	Channel	1,800' streambank protection	$83,000

The Estimated Capital Cost for each element includes Contractor profit, engineering, legal and contingencies. In addition, land purchase and severance costs are included where land is required. All costs are based upon June 1973 prices.

Total Estimated Capital Cost: $2,660,000

Round To: $2,700,000

** Detailed estimate obtained from City of Mercer Island

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative II   Sub-Basin Lake Washington East

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
42	Forbes Lake						Improvements to outlet and spillway to provide 4.5 AF of storage	$30,000
29	Pipe	48"	1,200'			Parallel Pipe	21"	$43,000
87	Channel	8'	1,200'	2:1	4'	Channel	1,200' streambank protection	$55,000
96	Pipe	48"	1,400'			Parallel Pipe	24"	$59,000
99	Pipe	42"	1,150'			Parallel Pipe	36"	$76,000
100	Pipe	24"	1,000'			Parallel Pipe	24"	$42,000
142	Pipe	15"	3,800'			Parallel Pipe	12"	$76,000
98	Pipe	15"	2,800'			Parallel Pipe	12"	$56,000
143	Pipe	15"	2,400'			Parallel Pipe	12"	$48,000
105	Channel						Enlarge capacity of concrete flume & divert portion of runoff to I-90 drainage for treatment	$26,000**
114	Channel						Install runoff detention basin to provide 3 AF of storage and diversion pipe	$250,000**
117	Channel						Divert from stream with storm drain system	$150,000**
161	Channel						Miscellaneous streambank protection and runoff detention basin	$75,000**
165	Channel						Runoff detention basin to provide 1+ AF storage	$25,000**
170	Channel						Runoff detention basin to provide 1+ AF storage and diversion pipeline	$185,000**
180	Channel						Install storm drain to reduce ditch flooding	$240,000***
81	Pipe	12"	3,300'			Parallel Pipe	30"	$178,000

** Detailed estimate obtained from City of Mercer Island

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

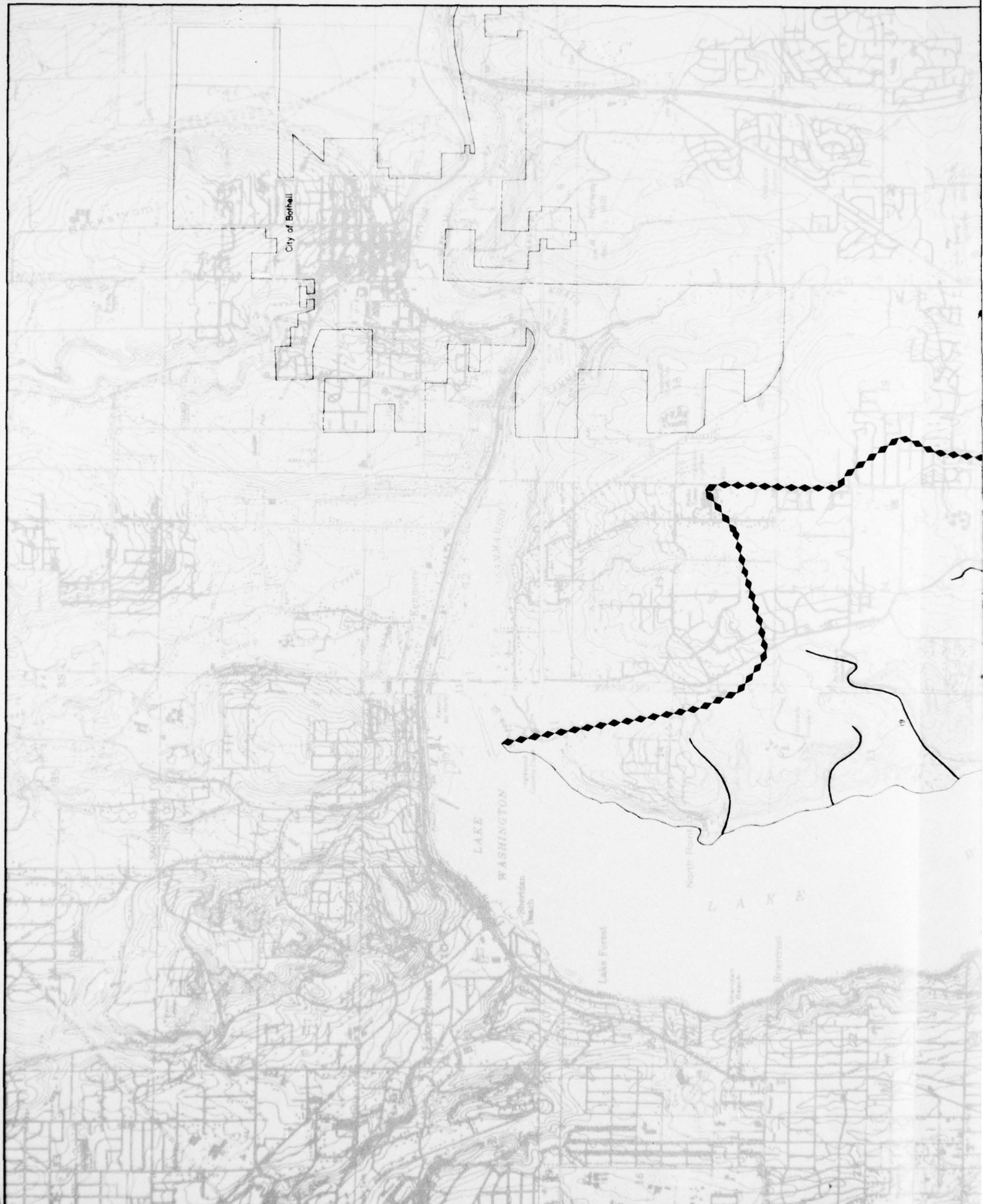
Alternative II Sub-Basin Lake Washington East

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
41	Channel	8'	6,500'	2:1	4'		Flood plain zone	-0-
144	Channel	8'	4,500'	2:1	4'		Flood plain zone	-0-
57	Channel	8'	2,500'	2:1	4'		Flood plain zone	-0-

The Estimated Capital Cost for each element includes Contractor profit, engineering, legal and contingencies. In addition, land purchase and severance costs are included where land is required. All costs are based upon June 1973 prices.

Total Estimated Capital Cost: $1,614,000

Round To: $1,600,000


City of Bothell
LAKE
WASHINGTON
L A K E
Lake Forest

LEGEND

SUB-BASIN BOUNDARY	
EXISTING CHANNEL	
EXISTING CONDUIT	
MANHOLE, INLET, OR JUNCTION	•
CHANNEL OR CONDUIT DESIG.	5
CITY LIMITS	
COUNTY (METRO) BOUNDARY	
LEVEE	
CULVERT	
HOLDING POND OR LAKE	

N

1/2 1/4 0 1
MILES
1000 500 0 4000
FEET

NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

LAKE WASHINGTON EAST

PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

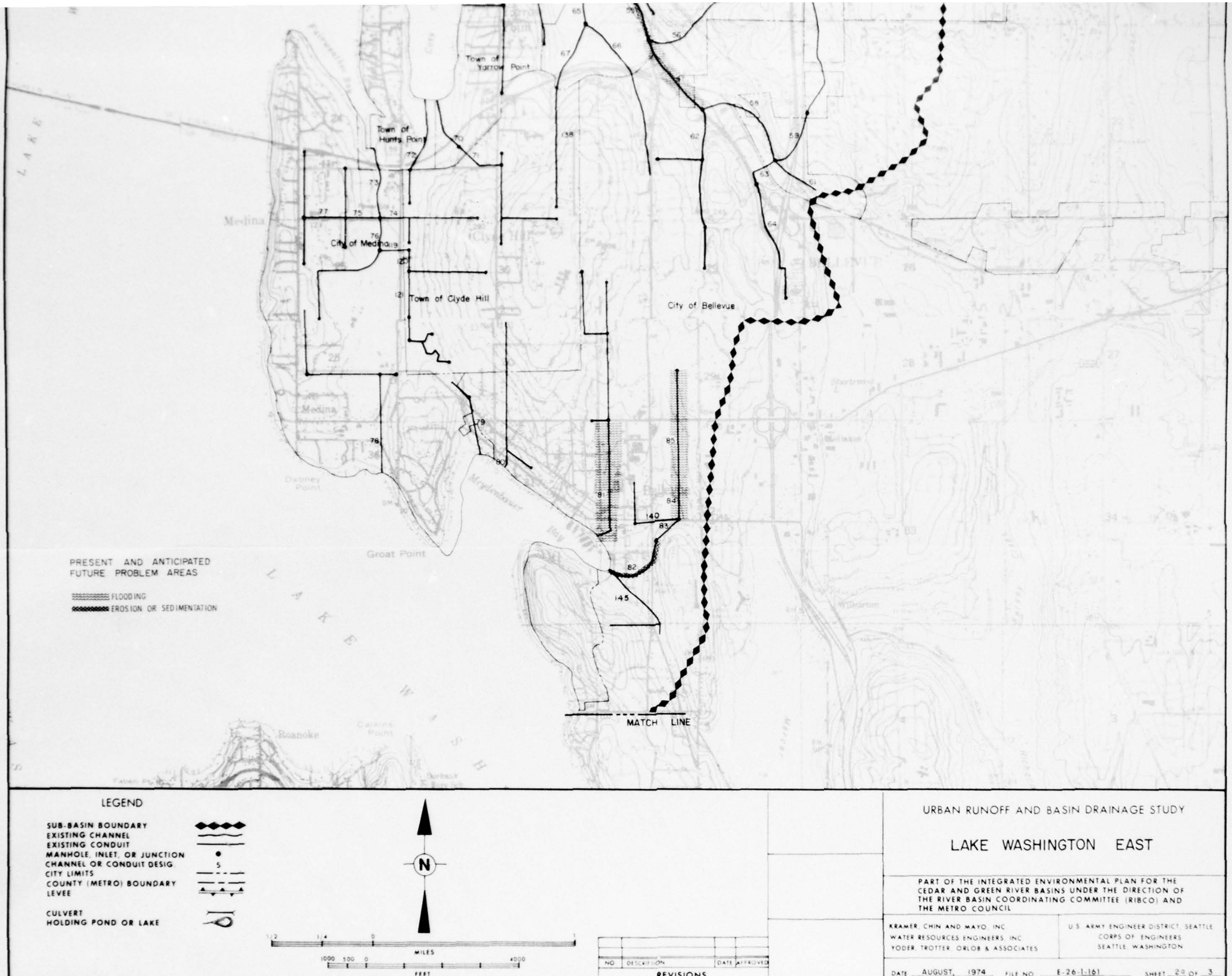
KRAMER, CHIN AND MAYO, INC
WATER RESOURCES ENGINEERS, INC
YODER, TROTTER, ORLOB & ASSOCIATES

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO E-26-1-161 SHEET 1 OF 3

2


City of Redmond
City of Kirkland
Houghton
Town of Yarrow Point
Hunt Point
Town of Hunts Point
LAKE WASHINGTON
Sand Pt
SEATTLE
U S NAVAL AIR STATION
Juanita Point



NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

LAKE WASHINGTON EAST

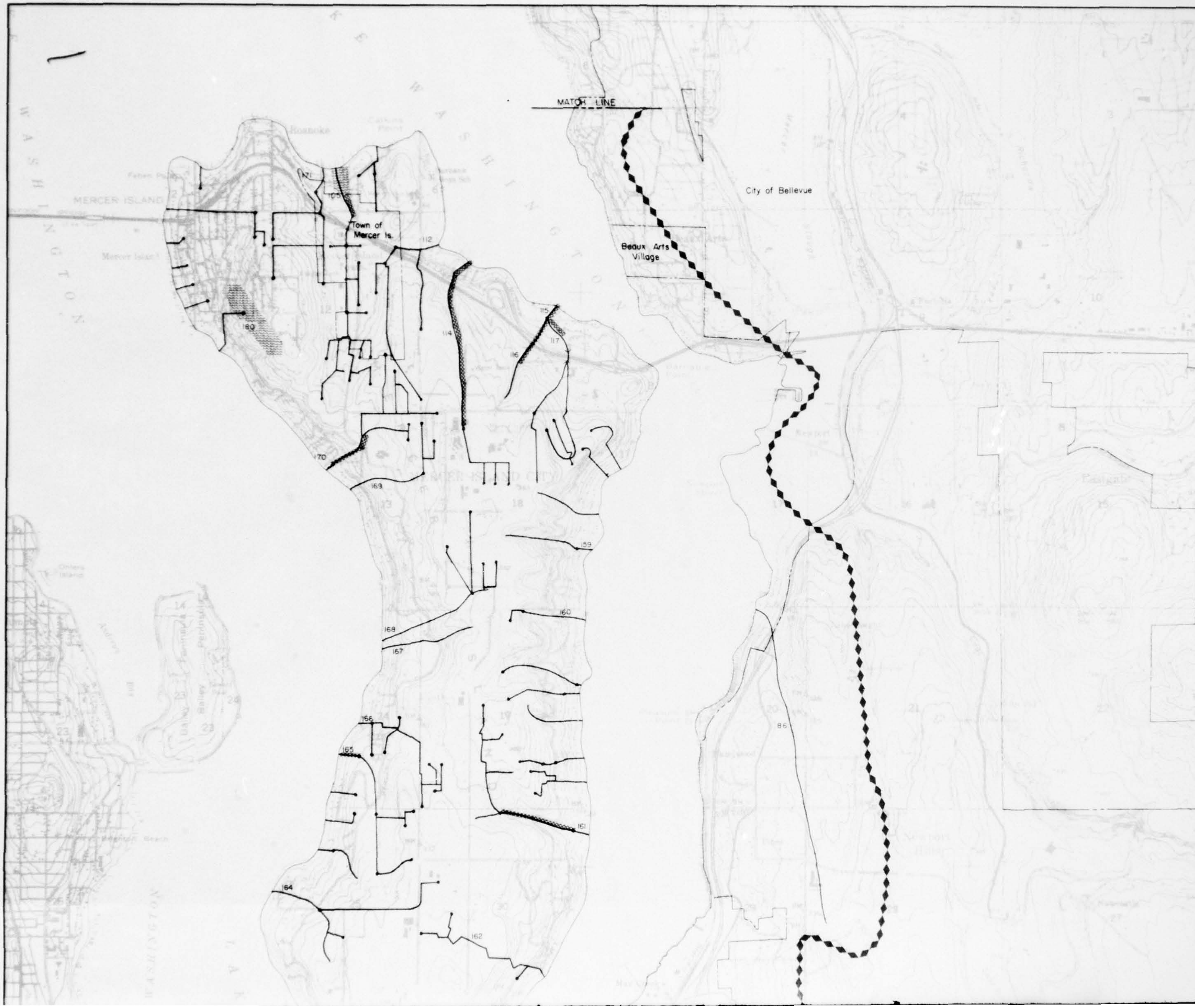
PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

KRAMER, CHIN AND MAYO, INC
WATER RESOURCES ENGINEERS, INC
YODER, TROTTER, ORLOB & ASSOCIATES

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO E-26-1-161 SHEET 2a OF 3

2


MATCH LINE
City of Bellevue
Beaux Arts Village
Town of Mercer Is.
MERCER ISLAND
105
112
114
115
116
117
159
160
161
162
164
165
166
167
168
169
170
171
180
86

LEGEND

SUB-BASIN BOUNDARY
EXISTING CHANNEL
EXISTING CONDUIT
MANHOLE, INLET, OR JUNCTION
CHANNEL OR CONDUIT DESIG.
CITY LIMITS
COUNTY (METRO) BOUNDARY
LEVEE

CULVERT
HOLDING POND OR LAKE

N

1/2 1/4 0 1
MILES
1000 500 0 4000
FEET

NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

LAKE WASHINGTON EAST

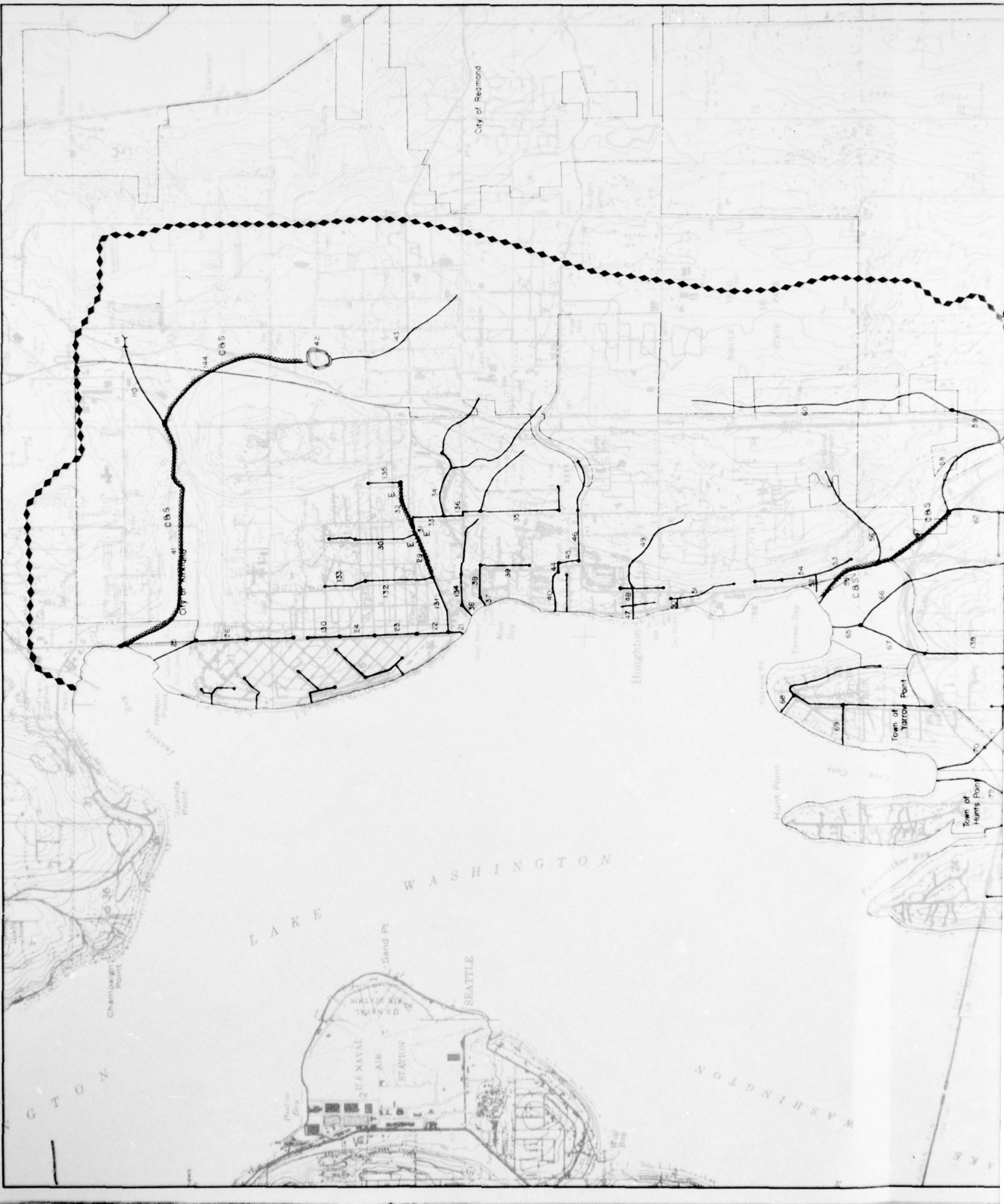
PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

KRAMER, CHIN AND MAYO, INC
WATER RESOURCES ENGINEERS, INC
YODER, TROTTER, ORLOB & ASSOCIATES

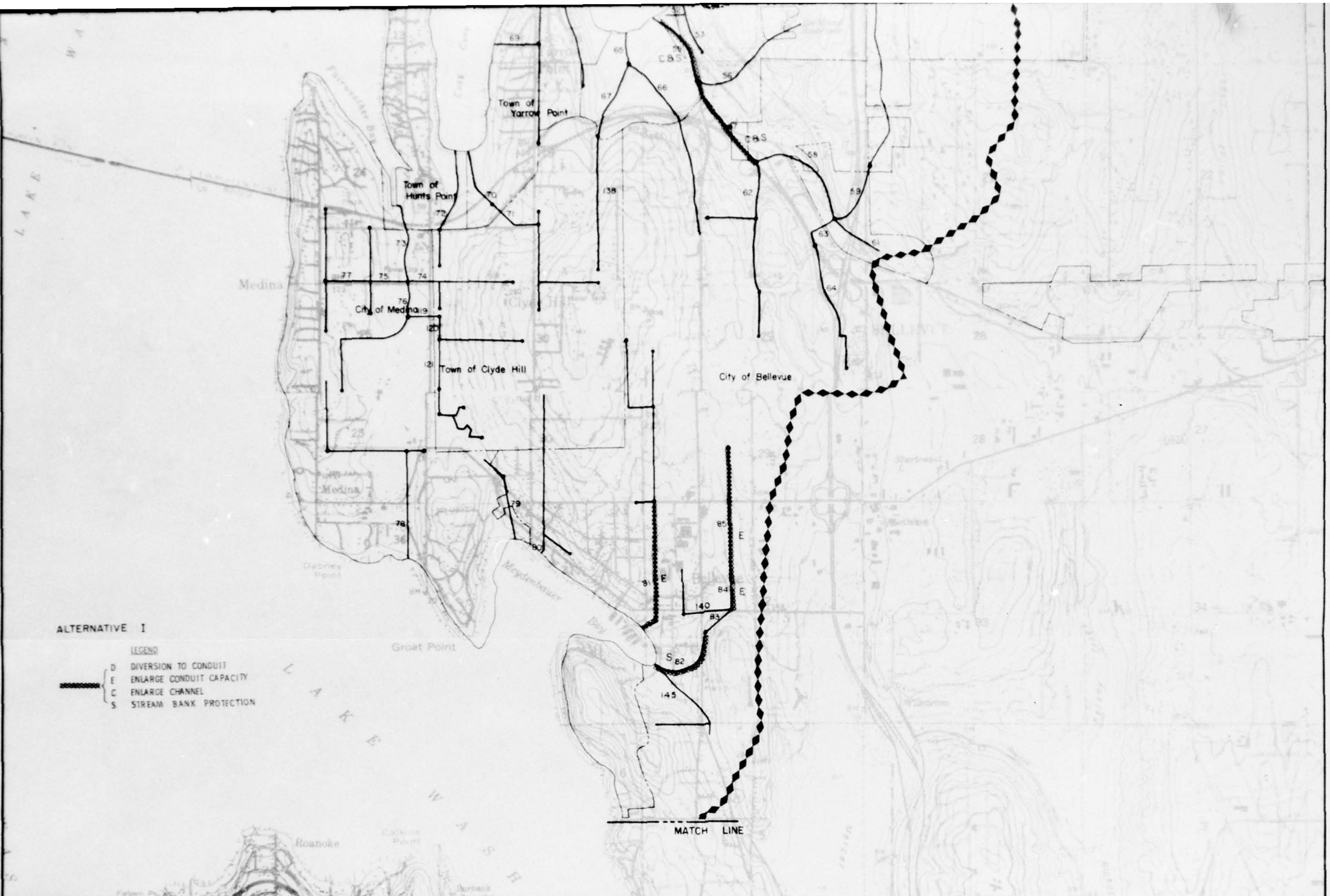
U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO E-26-1-161 SHEET 3B OF 3

2



City of Redmond
City of Kirkland
CBS
Houghton
Town of Yarrow Point
Town of Hunts Point
Hunt Point
Champaign Point
Sand Pt
SEATTLE
U.S. NAVAL AIR STATION
LAKE WASHINGTON



LEGEND

SUB-BASIN BOUNDARY
EXISTING CHANNEL
EXISTING CONDUIT
MANHOLE, INLET, OR JUNCTION
CHANNEL OR CONDUIT DESIG.
CITY LIMITS
COUNTY (METRO) BOUNDARY
LEVEE
CULVERT
HOLDING POND OR LAKE

N

MILES: 1/2 1/4 0 1

FEET: 1000 500 0 4000

NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

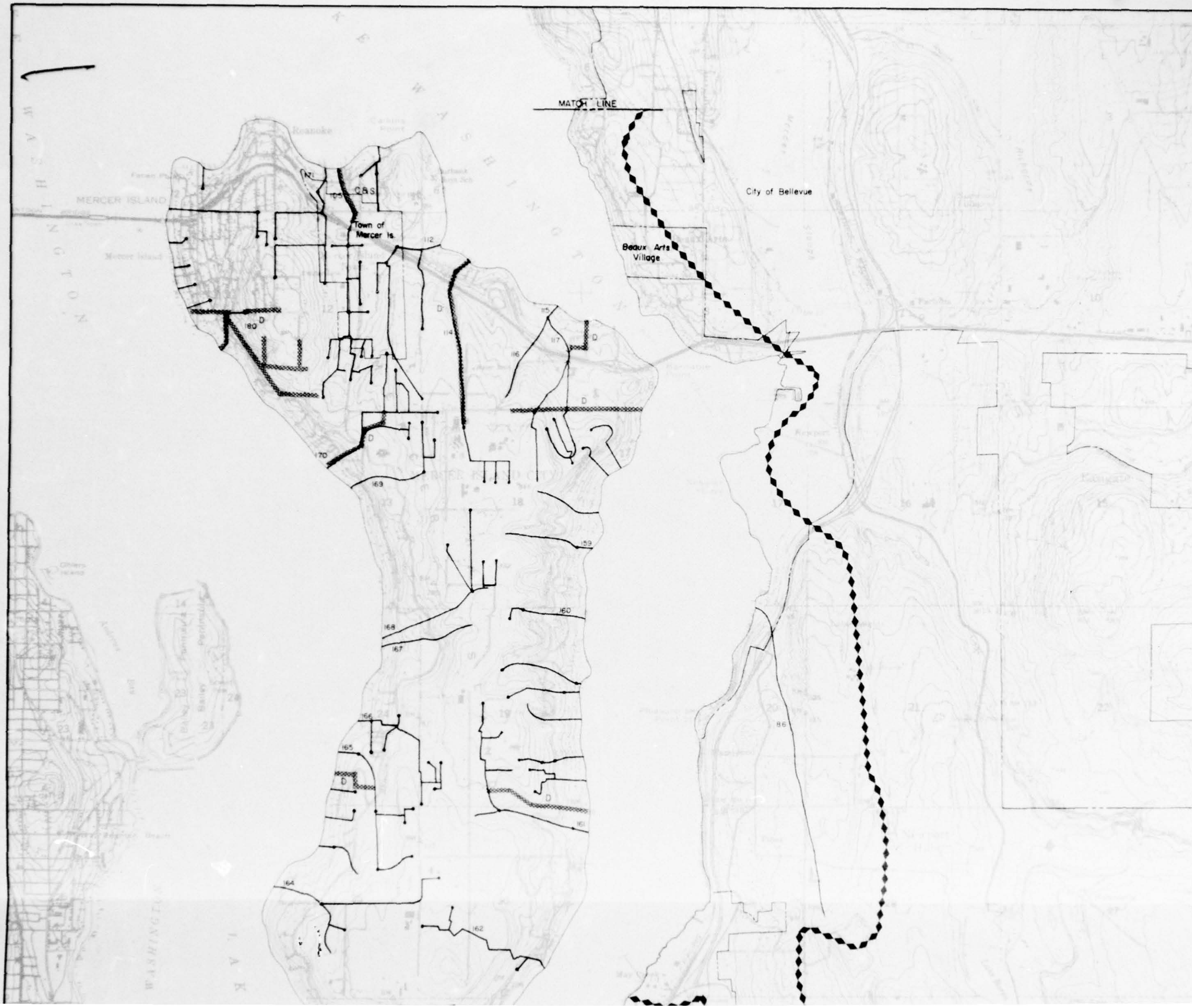
LAKE WASHINGTON EAST

PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

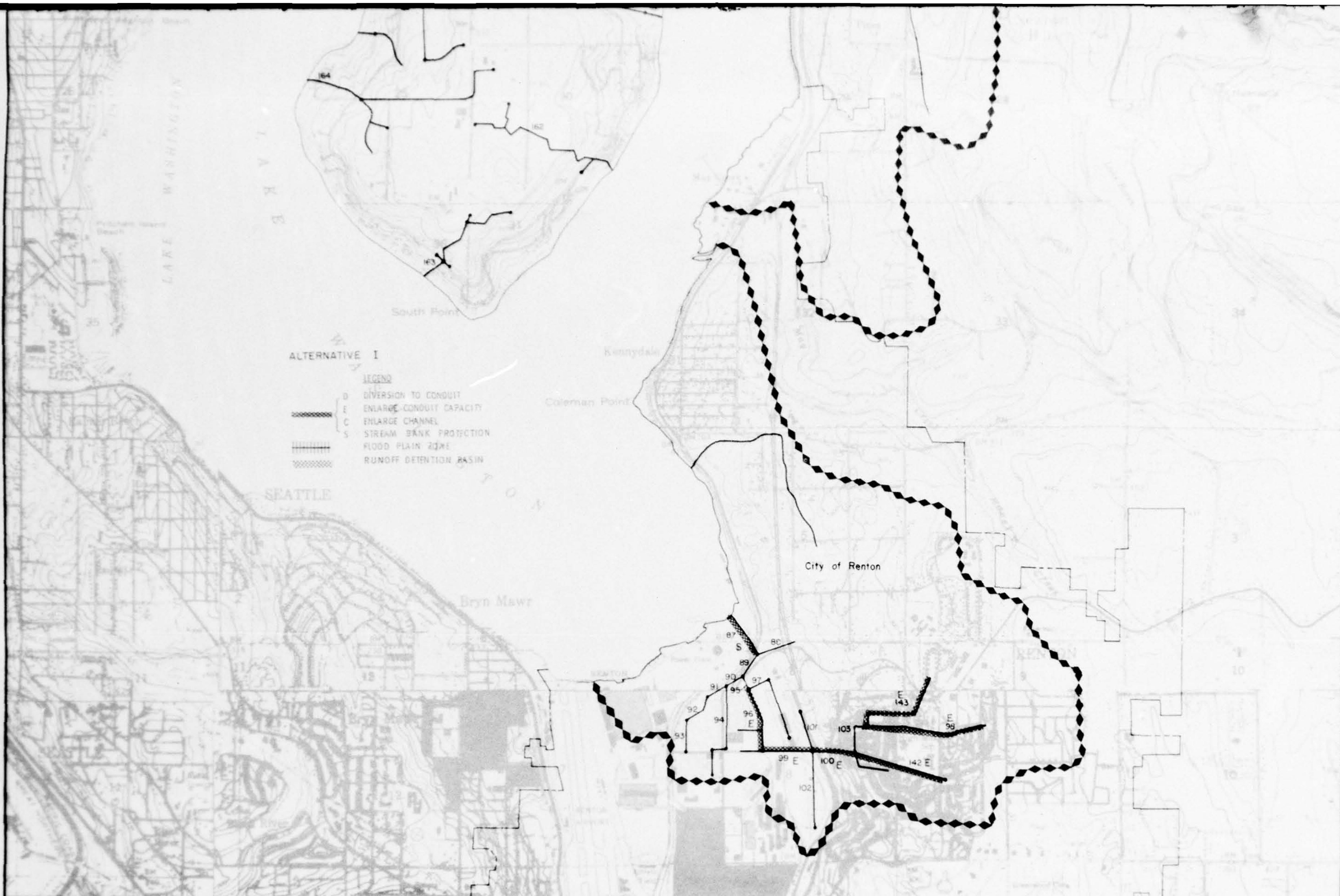
KRAMER, CHIN AND MAYO, INC.
WATER RESOURCES ENGINEERS, INC.
YODER, TROTTER, ORLOB & ASSOCIATES

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO. E-26-1-161 SHEET 2b OF 3



MATCH LINE
City of Bellevue
Beaux Arts Village
Town of Mercer Is.
MERCER ISLAND
Reanoke



LEGEND

SUB-BASIN BOUNDARY
EXISTING CHANNEL
EXISTING CONDUIT
MANHOLE, INLET, OR JUNCTION
CHANNEL OR CONDUIT DESIG. 5
CITY LIMITS
COUNTY (METRO) BOUNDARY
LEVEE
CULVERT
HOLDING POND OR LAKE

N

MILES: 1/2 1/4 0 1

FEET: 1000 500 0 4000

NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

LAKE WASHINGTON EAST

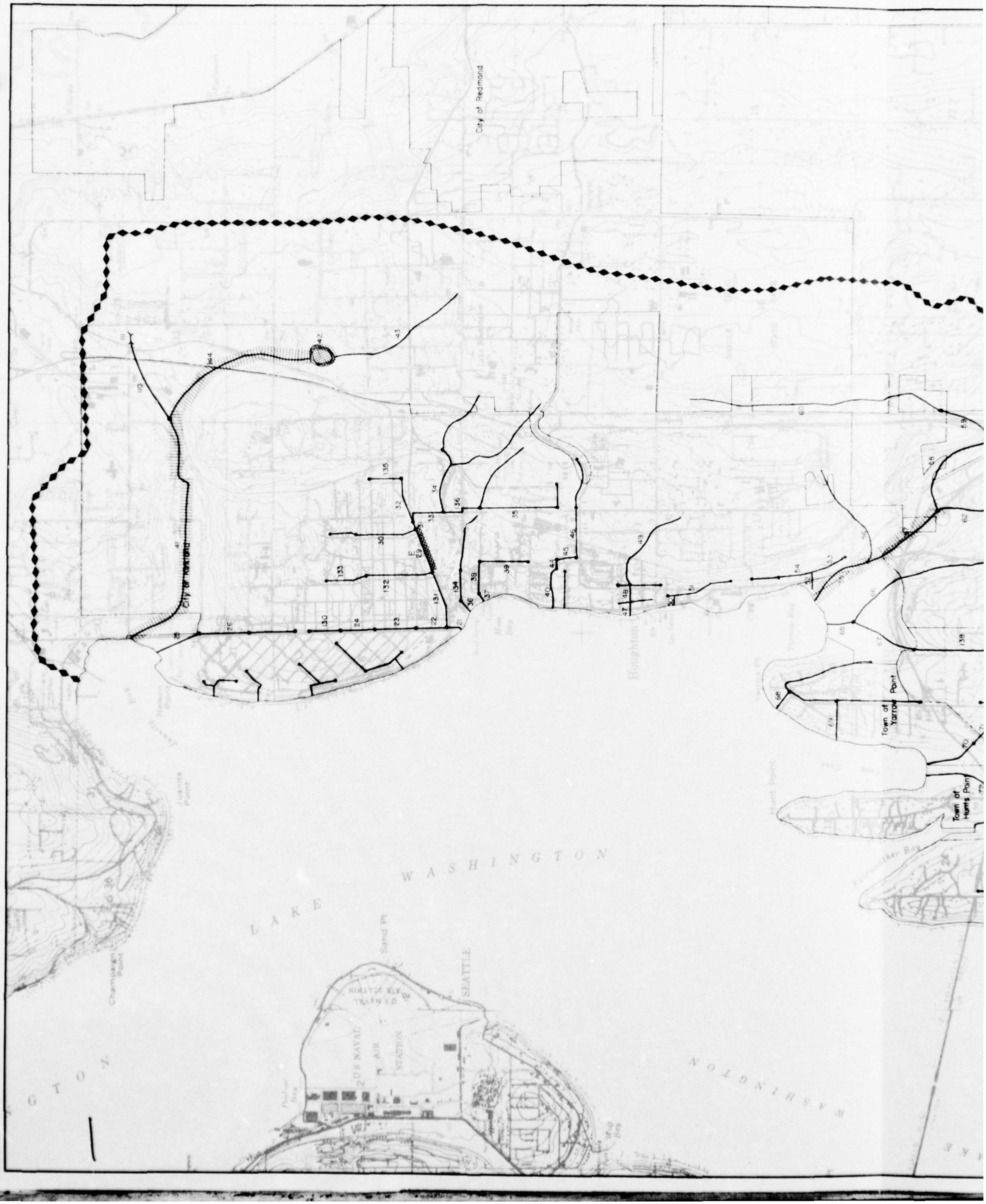
PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

KRAMER, CHIN AND MAYO, INC
WATER RESOURCES ENGINEERS, INC
YODER, TROTTER, ORLOB & ASSOCIATES

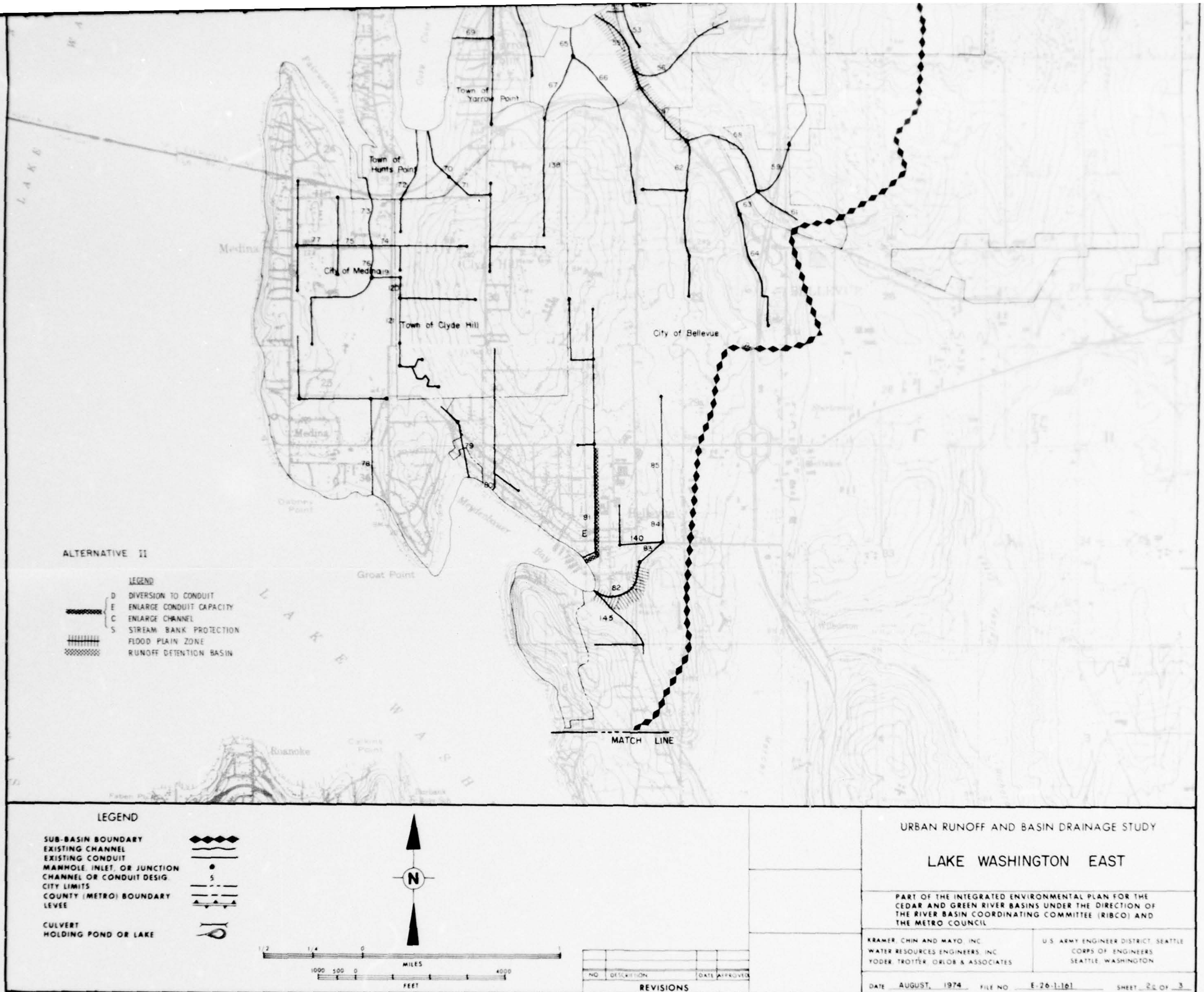
U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO E-26-1-161 SHEET 3 OF 3

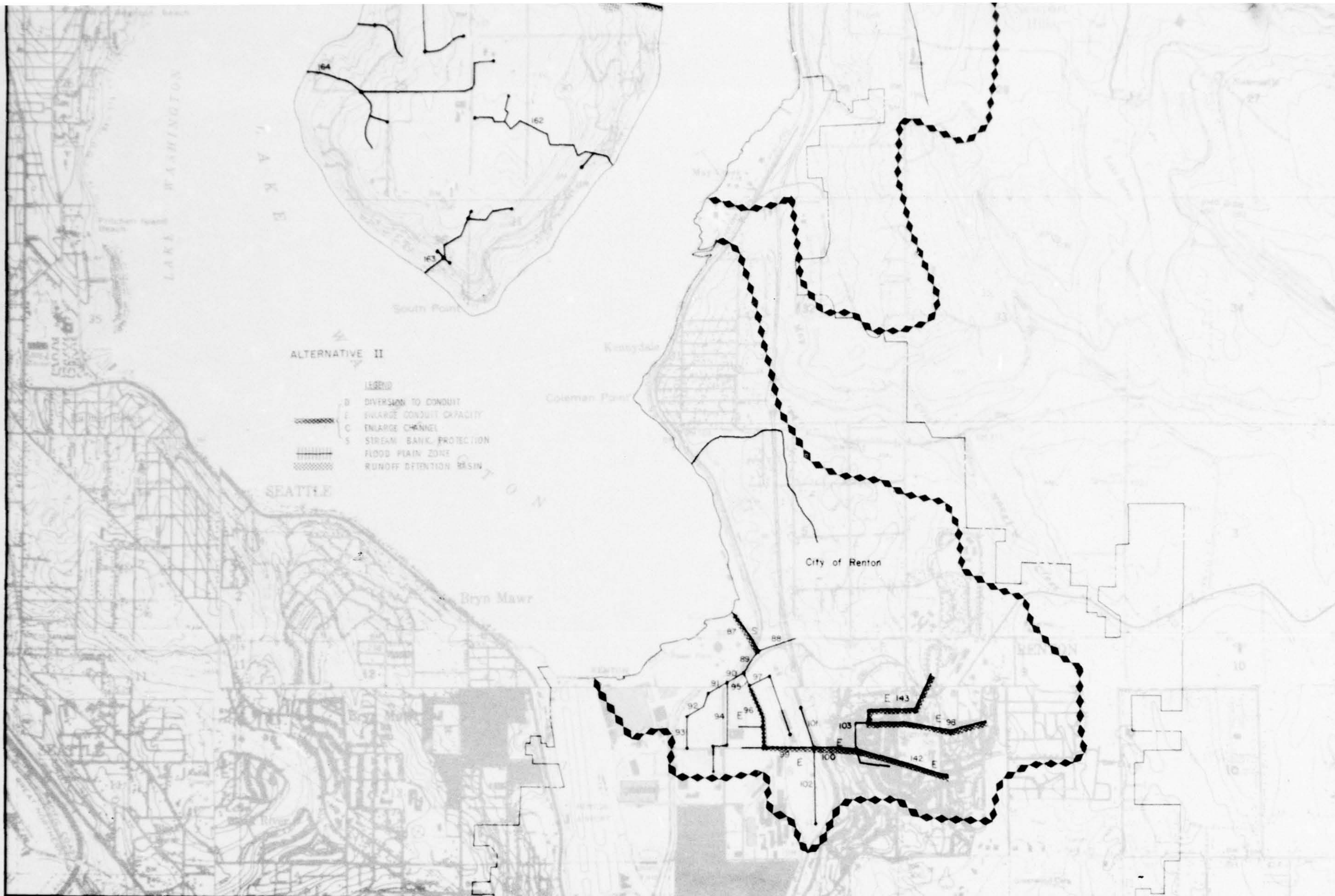
2



City of Redmond
City of Kirkland
Houghton
Town of Yarrow Point
Town of Hunts Point
Hunts Point
Juanita Point
Champagne Point
Sand Pt
SEATTLE
U S NAVAL AIR STATION
LAKE WASHINGTON
WASHINGTON


Town of Yarrow Point
Town of Hunts Point
City of Medina
Town of Clyde Hill
City of Bellevue
Medina
Groat Point
Meydenbauer Bay
LAKE WASHINGTON
MATCH LINE
ALTERNATIVE II
LEGEND
D DIVERSION TO CONDUIT
E ENLARGE CONDUIT CAPACITY
C ENLARGE CHANNEL
S STREAM BANK PROTECTION
FLOOD PLAIN ZONE
RUNOFF DETENTION BASIN
LEGEND
SUB-BASIN BOUNDARY
EXISTING CHANNEL
EXISTING CONDUIT
MANHOLE, INLET, OR JUNCTION
CHANNEL OR CONDUIT DESIG.
CITY LIMITS
COUNTY (METRO) BOUNDARY
LEVEE
CULVERT
HOLDING POND OR LAKE
N
MILES
FEET
NO DESCRIPTION DATE APPROVED
REVISIONS
URBAN RUNOFF AND BASIN DRAINAGE STUDY
LAKE WASHINGTON EAST
PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL
KRAMER, CHIN AND MAYO, INC.
WATER RESOURCES ENGINEERS, INC.
YODER, TROTTER, ORLOB & ASSOCIATES
U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON
DATE AUGUST, 1974 FILE NO E-26-1-161 SHEET 2c OF 3


MATCH LINE
City of Bellevue
Beaux Arts Village
Town of Mercer Is.
MERCER ISLAND
Roanoke
WASHINGTON
LAKE



LEGEND

SUB-BASIN BOUNDARY
EXISTING CHANNEL
EXISTING CONDUIT
MANHOLE, INLET, OR JUNCTION
CHANNEL OR CONDUIT DESIG.
CITY LIMITS
COUNTY (METRO) BOUNDARY
LEVEE
CULVERT
HOLDING POND OR LAKE

1/2 1/4 0 1 MILES
1000 500 0 4000 FEET

NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

LAKE WASHINGTON EAST

PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

KRAMER, CHIN AND MAYO, INC.
WATER RESOURCES ENGINEERS, INC.
YODER, TROTTER, ORLOB & ASSOCIATES

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO E-26-1-161 SHEET 3c OF 3

REGIONAL SUB-BASIN C-18

LAKE UNION

GENERAL DESCRIPTION

The Lake Union Sub-Basin is located entirely within the City of Seattle between Lake Washington and Puget Sound. Lake Union receives water from area storm drains and from Lake Washington by means of the Lake Washington Ship Canal. It dispenses water to Puget Sound by means of the ship canal and the government locks. Water flows into Lake Union from all directions and flows out to the west. There are no natural streams in the sub-basin and the level of Lake Union, a natural lake, has been altered by construction of the ship canal.

The sub-basin consists of gently rounded hills with peak elevations over 400 feet. It is 94% developed in intensive urban uses, including major transportation corridors; Interstate 5 and Aurora Avenue, and industrial areas bordering directly on Lake Union and the ship canal. The undeveloped land is made up primarily of the steep slopes of Queen Anne and Capital Hill that overlook Lake Union. The Lake represents 5% of the sub-basin's total area. Portions of the University of Washington, the Seattle Center, and Central Business District of Seattle are in this sub-basin.

PERCENT OF SUB-BASIN AREA IN SPECIFIED LAND USE

Land Use	Existing (1970-72)	P.S.G.C. Land Use Projection: Comprehensive	P.S.G.C. Land Use Projection: Corridor
Single Family	75	66	66
Multiple Family	5	10	10
Commercial/Services	5	8	10
Govt. and Educ.	2	2	2
Industrial	5	7	5
Parks/Dedicated Open Space	1	1	1
Agriculture			
Airports, Railyards, Freeways, Highways	1	1	1

Land Use	Existing (1970-72)	P.S.G.C. Land Use Projection Comprehensive	Corridor
Unused Land	1		
Water	5	5	5
Total	100	100	100
Total Impervious Area	45	55	55

There are no major trends toward land-use change in the basin as the character and pattern of development have been fixed for many years. There will be continuing rehabilitation of existing developments and some relatively minor changes. Projects of the scale of the Seattle Center probably will not occur in the forseeable future.

While the sub-basin is entirely within the City of Seattle, the Municipality of Metropolitan Seattle (Metro) is heavily involved in accommodation of storm-drainage runoff due to the existence of combined sanitary and storm sewers throughout the sub-basin. The public, in 1968, when presented with the problems existing because of the combined system, voted to construct separate storm-drain systems throughout much of Seattle, (Forward Thrust). Some separation in the Lake Union Sub-Basin was part of that authorization and has been nearly completed.

NATURE OF EXISTING DRAINAGE SYSTEM

The existing drainage system is either the storm drains being constructed as part of the Forward Thrust separation program, or the previously existing combination sanitary/storm sewer. Except for a portion of the North Queen Anne Hill at the ship canal, the entire sub-basin is served by one system or the other. Drainage carried in the combined system is fed to the Metro West Point Treatment Plant, where it is processed before release into Puget Sound. During major storms, the high volume of combined sewage exceeds the capacity of the sewer system and overflows of untreated sewage discharge to Puget Sound or Lake Union and the ship canal. Storm runoff collected by new storm drains is directed immediately into Lake Union or the ship canal without treatment.

DRAINAGE PROBLEMS

Problems of the Lake Union Sub-Basin are associated with the inadequate capacity of the combined sewer system to handle storm flows both at the point of entry to the system (resulting in flooded basements, yards, and streets) and the point of discharge at West Point or shoreside discharge structures where raw sewage from overflows is released into Puget Sound, Lake Union or the ship canal. The construc-

tion of storm drains discharging directly into Lake Union or the ship canal results in frequent localized introduction of pollutants associated with storm runoff as a trade-off for overflow discharge from the combined sewer system.

Completion of storm-sewer separation should relieve the overflow discharge of raw sewerage at West Point, Lake Union and the ship canal. The problem of the pollution from urban runoff will have to be corrected, probably with a combined effort by Metro and Seattle under the P.L. 92-500 Areawide Waste Treatment Management planning.

BASIC ISSUES AND STATUS OF DRAINAGE PLANNING

The City of Seattle and Metro are cooperating in planning for additional areas of separation that would, if funded, cover the entire Lake Union Sub-Basin. Funds authorized in 1968 cover only a portion of the entire proposed system.

ALTERNATIVE PLANS FOR PROPOSED DRAINAGE CONTROL

As the City of Seattle and Metro already are committed to a system to accommodate drainage in this sub-basin, it is unlikely that any other alternative courses of action are practical.

REGIONAL SUB-BASIN C-19

LAKE WASHINGTON WEST

GENERAL DESCRIPTION

The Lake Washington West Sub-Basin is located along the entire western shore of Lake Washington and extends from Renton in the south to Kenmore in the north. It contains four unnamed small streams and Union Bay, Green Lake and Haller Lake. Lake Washington now drains to the west through the Lake Washington Ship Canal to Puget Sound. In addition to direct runoff from this sub-basin, Lake Washington receives water from the Sammamish River, the Cedar River and numerous streams discussed elsewhere in the urban runoff and sub-basin-drainage study.

Geography of the basin consists of gently rounded hills reaching elevations of 500 feet. There are areas of abrupt topography and gullies throughout the basin. The western shore of Lake Washington contains a brief shelf at the water's edge that was created when the ship canal was completed and the lake level lowered.

The sub-basin is nearly 100 percent developed with the remaining undeveloped land in steep gullies and hillsides. All land-use activities typical of an intensely urbanized area are found in this basin, although industrial uses are minor. The basin contains extensive parklands, numerous scattered commercial areas, a portion of the University of Washington and the entire Sand Point Naval Base. Interstate 5, Aurora Avenue (SR-9) and SR-522 all pass through the basin.

PERCENT OF SUB-BASIN AREA IN SPECIFIED LAND USE

Land Use	Existing (1970-72)	P.S.G.C. Land Use Projection Comprehensive	Corridor
Single Family	80	74	73
Multiple Family	1	3	4
Commercial/Services	2	5	5
Govt. and Educ.	5	5	5
Industrial	2	3	3
Parks/Dedicated Open Space	10	10	10
Agriculture			

Land Use	Existing (1970-72)	P.S.G.C. Land Use Projection Comprehensive	Corridor
Airports, Railyards, Freeways, Highways			
Unused Land			
Water			
Total	100	100	100
Total Impervious Area	40	45	45

Future development will tend to fill out the existing pattern. The Sand Point Naval Base will change somewhat if property is transfered to the City of Seattle for a park and to the National Oceanic and Atmospheric Administration for a research base. The University of Washington controls extensive lands around its campus that could realize more intensive development.

The PSGC Year 2000 Comprehensive Plan indicates that some existing single-family use will change to multiple-family and commercial use. This projection is echoed by the year 2000 Corridor Plan.

The major portion of the sub-basin is within the City of Seattle, with King County and Snohomish County controlling the remainder. The Municipality of Metropolitan Seattle provides sewer service to that portion of the sub-basin within Seattle and King County. Public interest in drainage control in the sub-basin was reflected by approval of bonds in the 1968 Forward Thrust election to finance separation of the combined sanitary and storm sewer system that existed throughout most of the basin. The separation project is now nearing completion.

NATURE OF EXISTING DRAINAGE SYSTEM

The drainage system in the sub-basin consists of storm drains, combined sewers, and areas with natural drainage that utilize small streams as the receiving water. Haller Lake and Green Lake receive runoff from their immediate environs and it is transfered to Lake Washington by pipes and open channel. The combined sewer system contains numerous pump stations. Certain components of the system provide for intense human use and enjoyment. Haller Lake, Green Lake, and Lake Washington all provide excellent recreational opportunities for boating, swimming, and fishing. They provide wildlife habitats that allow many animals, fishes, and birds to survive in the urban setting. The streamways are incorporated into the deveopment of parks and residential properties and provide a unique amenity. All water bodies in the basin support fish life, with trout fishing in Green Lake and salmon fishing in Lake Washington being popular pastimes of area residents.

DRAINAGE PROBLEMS

Areas within this sub-basin which have been analyzed do not include those within the City of Seattle that have a combined sanitary and storm drainage system. This sub-basin is further divided into three principal sub-areas namely, North City, View Ridge, and Bryn Mawr.

There have been few reported or observed problems within these sub-areas. However, runoff simulation of the drainage systems under the projected year 2000 land-use conditions indicate that the capacities of several storm drains and culverts would be exceeded. Soil-erosion and slides have occurred on the steep bluff on Lake Washington near Briercrest.

The results of hydrologic analysis indicate no significant difference between the Comprehensive and Corridor Plans. Therefore, the drainage alternatives presented herein are applicable to both plans.

BASIC ISSUES AND STATUS OF DRAINAGE PLANNING

The City of Seattle, through Forward Thrust, is separating portions of the combined system by providing new storm drains. This is being done from Rainier Beach to Sand Point Naval Base, and storm-drain service will be provided for most of the sub-basin. Problems of discharge of raw sewage into Lake Washington should be eliminated when work is completed.

ALTERNATIVE PLANS FOR PROPOSED DRAINAGE CONTROL

The existing drainage system of the Lake Washington West Sub-Basin, as described by local agencies, was evaluated by computer simulation that applied the region's 10-year storm to year 2000 land use. Drainage problems thus identified were analyzed and possible solutions provided in development of alternative plans for drainage control as described below.

Two major alternative plans were studied for solving the Lake Washington West drainage problems. The first alternative enlarges existing storm-drainage conduits and open channels to alleviate predicted flood condition and also open channels are lined for high-flow velocities which would cause excessive erosion. The second alternative plan would preserve the existing quality of the major natural streams by specifying diversion-drainage facilities where appropriate. Holding ponds also are utilized to reduce peak flow rates. Otherwise, the improvements are the same as those for Alternative Plan I.

ALTERNATIVE PLAN I

General Concept

The general concept of Alternative Plan I is to increase the capacity of the system by the enlargement of existing storm-drainage

conduits and by opening channels to alleviate predicted flood conditions. It also is necessary under this alternative to line open channels where high flow velocities would cause excessive erosion.

Major Features

An open channel system is the major trunk drain from Brier to Kenmore. Several existing culverts along this stream that cross Bothell Way would severely constrict anticipated runoff from a 10-year storm. The culvert on the main stream would need to be enlarged and streambank protection be provided for the lower half of the channel. The west ridge from Sand Point Naval Station northward features many small pipes and culverts that discharge runoff directly into Lake Washington. Several of the culverts along Lake Washington from Lake Forest to Briercrest could need to be enlarged. The View Ridge system consists exclusively of underground storm drainage conduits and only a few additional supplemental conduits are needed. The major constriction within this system seems to be the outfall going into Lake Washington. Two open channel systems accommodate the major drainage within the Bryn Mawr sub-area. No surcharging was noted for the systems in Bryn Mawr, however velocities of flow in the steeper reaches would indicate the need for channel protection.

Cost

The capital cost of improvements for Alternative Plan I is estimated to be $1,100,000.

Improvements to the existing system would be expected to only slightly increase the present level of operation and maintenance. Protection of streambanks against excessive erosion should actually reduce sediment accumulation along the flatter stream reaches as well as minimize maintenance.

Each of the systems within the Lake Washington West Sub-Basin act independently and therefore little coordination between King County and the City of Seattle would be necessary to carry out any programs identified. This alternative plan is believed to be relatively easy to accomplish, however it may have some questionable environmental results.

ALTERNATIVE PLAN II

General Concept

In this alternative plan, provision is made to preserve the existing quality of the major natural streams by specifying diversion-drainage facilities where appropriate. Holding ponds also are utilized to reduce peak flow rates. Otherwise, the improvements are the same as those for Alternative Plan I.

Major Features

The lower reach of the main stream from Brier to Kenmore is bordered by 61st Avenue arterial which would provide access to drainage conduit construction. A diversion along 61st would alleviate flow conditions in the natural channel and would eliminate the need for rip-rap or other channel protection. A holding pond near 241st Street would reduce peak flows to the stream even more. A small pond site also is specified just above Bothell Way at Acacia Cemetery as an alternative to enlargement of the culvert. Two diversion pipes also are recommended for the Bryn Mawr sub-area. As these diversion pipes will intercept the major portion of runoff into these streams, no streambank protection will be necessary.

Cost

The total cost for drainage-system improvements is estimated to be $1,700,000.

A substantial portion of that cost is for the diversion pipe along 61st Avenue and the holding pond. Maintenance would be required for periodic cleaning of the holding ponds in addition to the requirements already discussed in Alternative Plan I.

Alternative Plan II would preserve and enhance the quality of those remaining natural streams within the sub-basin. Diversion of flows into proposed trunk drains and holding ponds would reduce peak flow rates. However, this alternative plan would cost considerably more than Alternative Plan I, but is more amenable to the environment.

As in Alternative Plan I, the systems within the sub-basin are all independent and therefore little cooperation between King County and the City of Seattle will be necessary to realize this alternative.

PEAK FLOW COMPARISONS

The following table indicates 10-year peak flows with existing facilities and land use and with alternative drainage management solutions for the year 2000.

COMPARISON OF 10-YEAR PEAK FLOWS
(Cubic Feet per Second)

Location	Existing Facilities	Alternative Plan I	Alternative Plan II
Bothell Way at Kenmore	160	370	200*
Outfall near Lake Forest	20	40	20*
View Ridge Main Outfall	140	350	350
Lake Ridge Ravine	160	200	120*
Outfall west of Renton Airport	200	250	250

*Flows reduced because of diversion conduits.

ENVIRONMENTAL ASSESSMENT OF ALTERNATIVE PLANS

Field inspections were made to judge applicability of the suggested alternative plans for this basin. This procedure was followed throughout the RIBCO study for development of alternative plans for the various regional sub-basins. The inspections were based upon the alternative evaluation procedure which identified 34 unique criteria grouped in general categories as follows: 1) Effectiveness, 2) Human Values, 3) Environmental Factors, 4) Implementation, and 5) Resource Requirements.

The various structural solutions were checked against the appropriate criteria and the various non-structural solutions were reviewed for their relationship to existing and probable future developments. The criteria rating total for Alternative Plan I, which basically employs enlargement of culverts along with streambank protection, was a minus 15 out of a possible range from a positive total of 108 and a negative total of 108. The total evaluation rating for Alternative Plan II, which employs diversions and holding ponds in addition to enlargement of culverts, was a plus 4.

Both alternative plans were judged to be effective in controlling drainage. Both plans involved certain sacrifices of human value and human uses of the land once they are built. However, Alternative Plan I appears to be detrimental to the aesthetics of the natural streams in the Kenmore and Bryn Mawr areas. Environmentally, Alternative Plan II offers more resource preservation potential than Alternative Plan I. There is streambank protection along a good deal of the creek in the Kenmore area and in the Bryn Mawr sub-area. None of the systems within either alternative plan is part of present planning of either of the involved agencies, City of Seattle or King County. However, cooperation

between the two agencies will not be required in order to accomplish any of the work. Each of the two agencies can proceed independently to carry out any of the projects within the two alternatives. Both of the two alternative plans involve commitments of the use and management of natural resources because they rely upon certain structural treatments for all or part of their solutions; therefore, neither alternative plan can be said to be clearly superior in this concern.

CONCLUSIONS

Alternative Plan II is superior to Alternative Plan I in that it protects the valuable urban amenities of the creeks in the Bryn Mawr and Kenmore areas, however, at a greater cost over Alternative Plan I.

Because of the independence of the systems within this sub-basin, King County and the City of Seattle should proceed independently to establish respective master plans for the drainage systems within the sub-basin that incorporate the provisions of Alternative Plan II. The timing of construction of the proposed improvements is not of the utmost importance at this time. The work should go ahead as development in these regions indicates.

RUNOFF QUALITY SUMMARY
LAKE WASHINGTON WEST

BASED UPON A 10-YEAR STORM PRECEDED BY 15 DAYS WITH LITTLE OR NO RAINFALL#

LOCATION	ALTERNATIVE PLAN	PEAK FLOW (cfs)	CONCENTRATION AT PEAK FLOW*				
			BOD	TOTAL COLIFORM	NH_3	$NO_2 + NO_3$	PO_4
	2000 Comprehensive Land Use						
Bothell Way	I & II	370**	12	1.0×10^5	.3	.8	.1
View Ridge	I & II	350	11	1.5×10^5	.2	.8	.1
Lake Ridge Ravine	I & II	200**	6	1.2×10^5	.1	.5	0
Renton Airport	I & II	250	13	1.4×10^5	.2	.8	.3

Less than a total of 0.5 inches of rainfall in any one day.
* Concentrations in mg/liter except total coliform which is in MPN/100 ml.
** Combined peak flows for channel and diversion pipe.

EVALUATION MATRIX

LAKE WASHINGTON WEST

ALTER-NATIVES	SUB TOTAL	EFFECTIVENESS: Use of existing facilities	System reliability	System maintainability	System flexibility	Flood damage reduction	Consequences of overcharge	Erosion and sedimentation control	Cost/benefits ranking	SUB TOTAL	HUMAN VALUES: Urban quality (aesthetics)	Effect on land use	Displacement of people	Educational value	Community cohesion	Multiple use potential	Public health and safety	SUB TOTAL	ENVIRONML.vTAL FACTORS: High flow conditions	Alteration of natural system	Effects on groundwater	Low flow conditions	Water quality	Construction disruption	Effects on wildlife	Effects on aquatic life	Effects on vegetation	SUB TOTAL	IMPLEMENTATION: Legislative requirements	Jurisdictional	Land acquisition	Public acceptance	Financing	Effects of no action	SUB TOTAL	RESOURCE REQUIREMENTS: Energy	Materials	Land	Capital	RATING TOTAL
		CRITERIA WEIGHT 1	4	3	2	4	4	4	2		CRITERIA WEIGHT 4	2	2	1	3	3	4		CRITERIA WEIGHT 4	4	4	4	4	2	4	4	4		CRITERIA WEIGHT 4	4	2	4	4	3		CRITERIA WEIGHT 3	3	2	2	
I	+6									-2								-8										-3							-8					-15
II	+12									+5								+2										-9							-6					+4

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative I Sub Basin Lake Washington West

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
13	Pipe	24"	100'			Parallel Pipe	36" Includes inlet and outlet	$13,000
11	Pipe	24"	300'			Parallel Pipe	42" Includes inlet and outlet	$30,000
12	Pipe	24"	1,450'			Parallel Pipe	36"	$96,000
2	Pipe	Two-36"	200'			Parallel Pipe	54"	$30,000
1	Channel	8'	550'	2:1	4'	Channel	3' depth Streambank protection	$28,000
3	Channel	8'	250'	2:1	4'	Channel	3' depth Streambank protection	$13,000
5	Channel	8'	1,500'	2:1	4'	Channel	3' depth Streambank protection	$76,000
6	Channel	8'	5,900'	2:1	4'	Channel	2' depth Streambank protection, lower 4,500'	$152,000
8	Channel	6'	2,500'	2:1	3'	Channel	2' depth Streambank protection, lower 1,500'	$51,000
14	Pipe	18"	100'			Parallel Pipe	36" Includes inlet and outlet	$12,000
15	Pipe	12"	150'			Parallel Pipe	27" Includes inlet and outlet	$11,000
16	Pipe	12"	150'			Parallel Pipe	24" Includes inlet and outlet	$10,000
17	Pipe	24"	150'			Parallel Pipe	21" Includes inlet and outlet	$9,000
18	Channel	6'	850'	2:1	3'	Channel	1' depth Streambank protection	$14,000
19	Pipe	18"	150'			Parallel Pipe	15" Includes inlet and outlet	$6,000
87	Pipe	42"	650'			Parallel Pipe	36"	$43,000
96	Pipe	21"	550'			Parallel Pipe	18"	$17,000

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative I   Sub Basin Lake Washington West

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
80	Pipe	60"	700'			Parallel Pipe	72"	$104,000
51	Channel	6'	3,000'	2:1	4'	Channel	3' depth Streambank protection	$101,000
53	Channel	6'	2,400'	2:1	4'	Channel	2' depth Streambank protection	$81,000
44	Channel	4'	2,800'	2:1	3'	Channel	1' depth Streambank protection	$47,000
41	Channel	4'	5,000'	2:1	3'	Channel	2.5' depth Lower 3,000' Streambank protection	$126,000

The Estimated Capital Cost for each element includes Contractor profit, engineering, legal and contingencies. In addition, land purchase and severance costs are included where land is required. All costs are based upon June 1973 prices.

Total Estimated Capital Cost: $1,070,000

Round To: $1,100,000

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative II Sub Basin Lake Washington West

ELEMENT NUMBER	EXISTING FACILITIES TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX DEPTH OF CHANNEL	PROPOSED FACILITIES TYPE		ESTIMATED CAPITAL COST
13	Pipe	24"	100'			Parallel Pipe	36" Includes inlet and outlet	$13,000
11	Pipe	24"	300'			Parallel Pipe	42" Includes inlet and outlet	$30,000
12	Pipe	24"	1,450'			Parallel Pipe	36"	$96,000
2	Pipe	Two-36"	200'	2:1	4'	Parallel Pipe	36" Includes inlet and outlet	$19,000
8	Channel	6'	2,500'	2:1	3'	Diversion Pipe	36" 2,000'	$132,000
6	Channel	8'		2:1	4'	Diversion Pipe	48" 4,000'	$372,000
5	Channel	8'		2:1	4'	Diversion Pipe	60" 1,500'	$180,000
1	Channel	8'		2:1	4'	Diversion Pipe	54" 1,000'	$106,000
7	Channel	6'	5,100'	2:1	4'	Holding Pond	3.3 AF 1.0 acre	$13,000
14	Pipe	18"	100'			Parallel Pipe	36" Includes inlet and outlet	$12,000
15	Pipe	12"	150'			Parallel Pipe	27" Includes inlet and outlet	$11,000
16	Pipe	12"	150'			Parallel Pipe	24"	$10,000
18	Channel	6'	3,100'	2:1	3'	Holding Pond	.5 AF .25 acre	$2,000
19	Pipe	18"	150'			Parallel Pipe	15" Includes inlet and outlet	$5,000
87	Pipe	42"	650'			Parallel Pipe	36"	$43,000
96	Pipe	21"	550'			Parallel Pipe	18"	$17,000
80	Pipe	60"	700'			Parallel Pipe	72"	$104,000

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

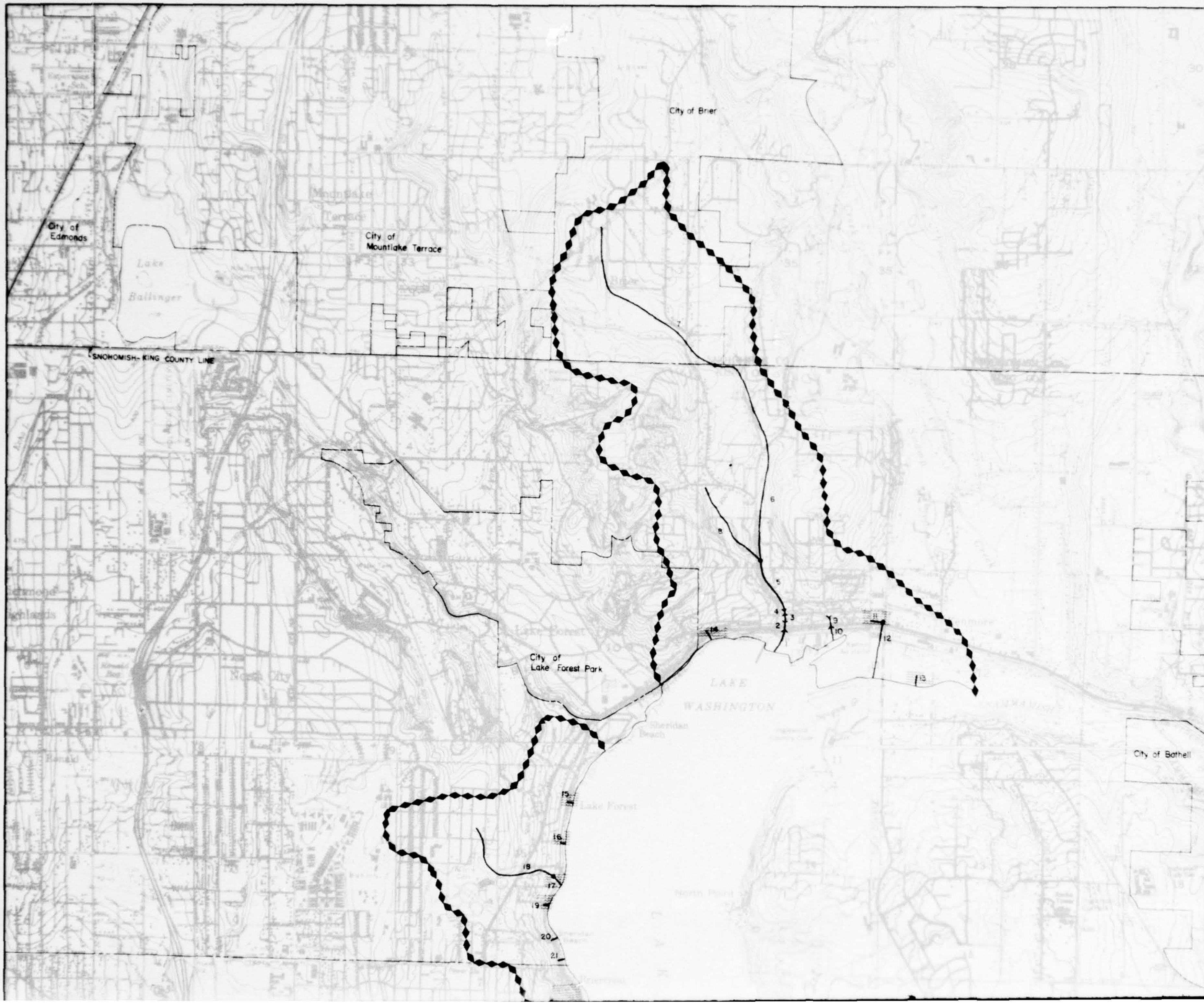
Alternative II   Sub-Basin Lake Washington West

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
51	Channel	6'	3,000'	2:1	4'	Diversion Pipe	30" 3,300'	$178,000
53	Channel	6'	2,400'	2:1	4'	Diversion Pipe	30" 2,400'	$130,000
44	Channel	4'	2,800'	2:1	3'	Channel	1' depth Streambank protection	$47,000
41	Channel	4'	5,000'	2:1	3'	Diversion Pipe	30" 3,000'	$162,000

The Estimated Capital Cost for each element includes Contractor profit, engineering, legal and contingencies. In addition, land purchase and severance costs are included where land is required. All costs are based upon June 1973 prices.

Total Estimated Capital Cost: $1,682,000

Round To: $1,700,000


City of Brier
City of Edmonds
City of Mountlake Terrace
SNOHOMISH- KING COUNTY LINE
City of Lake Forest Park
LAKE WASHINGTON
City of Bothell
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21

LEGEND

SUB-BASIN BOUNDARY
EXISTING CHANNEL
EXISTING CONDUIT
MANHOLE, INLET, OR JUNCTION
CHANNEL OR CONDUIT DESIG. 5
CITY LIMITS
COUNTY (METRO) BOUNDARY
LEVEE

CULVERT
HOLDING POND OR LAKE

N

1/2 1/4 0 1
MILES
1000 500 0 4000
FEET

NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

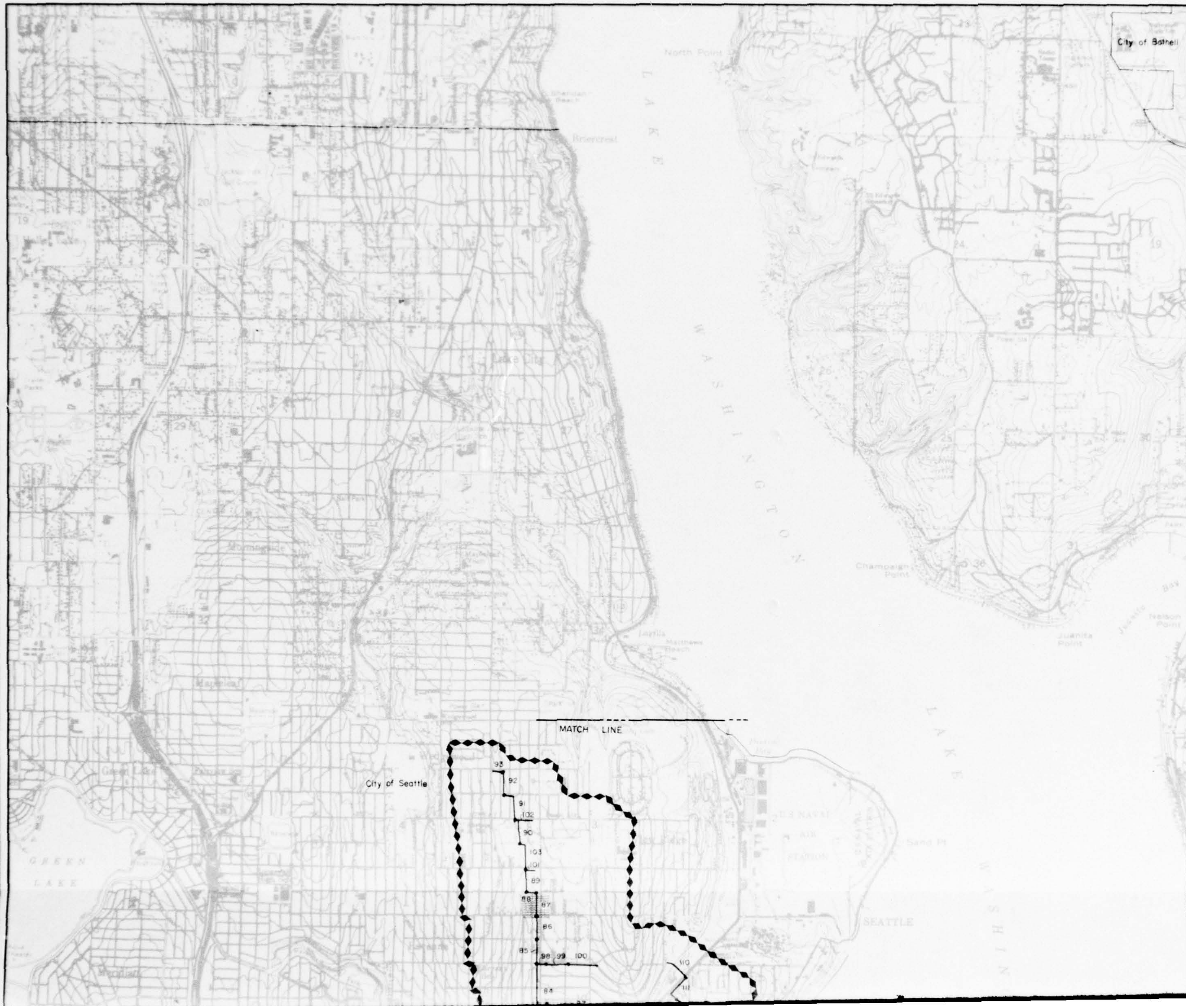
LAKE WASHINGTON WEST

PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

KRAMER, CHIN AND MAYO, INC
WATER RESOURCES ENGINEERS, INC
YODER, TROTTER, ORLOB & ASSOCIATES

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO E-26-1-161 SHEET 1D OF 3


City of Bothell
North Point
Briercrest
LAKE WASHINGTON
Champaign Point
Juanita Point
Juanita Bay
Nelson Point
Lake City
Laurelhurst
Matthews Beach
MATCH LINE
City of Seattle
U.S. NAVAL AIR STATION
Sand Pt
SEATTLE
GREEN LAKE
93
92
91
102
90
103
101
89
88
87
86
85
98
99
100
84
110
111

LEGEND

SUB-BASIN BOUNDARY
EXISTING CHANNEL
EXISTING CONDUIT
MANHOLE, INLET, OR JUNCTION
CHANNEL OR CONDUIT DESIG 5
CITY LIMITS
COUNTY (METRO) BOUNDARY
LEVEE

CULVERT
HOLDING POND OR LAKE

1/2 1/4 0 1 MILES

1000 500 0 4000 FEET

NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

LAKE WASHINGTON WEST

PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

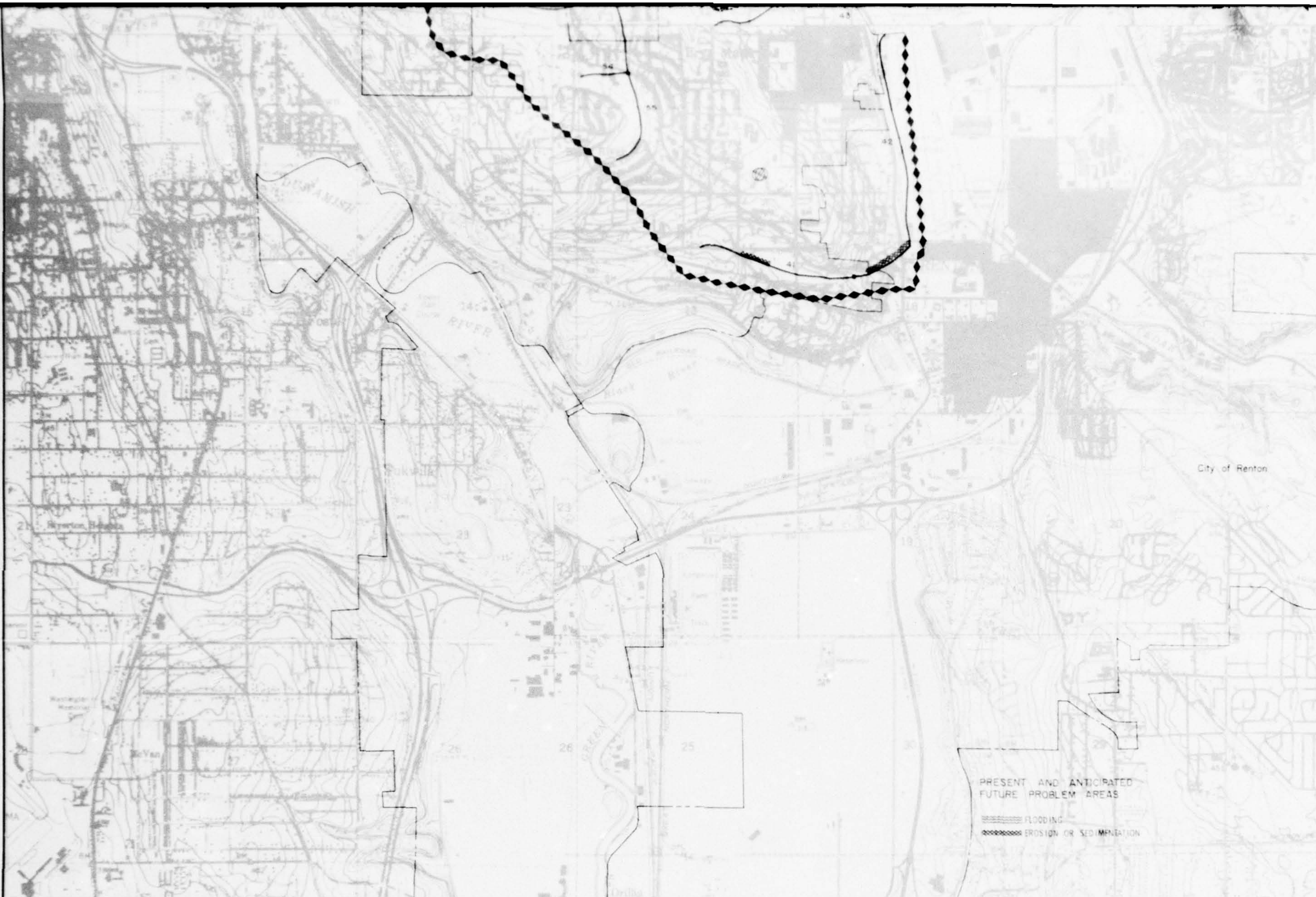
KRAMER, CHIN AND MAYO, INC
WATER RESOURCES ENGINEERS, INC
YODER, TROTTER, ORLOB & ASSOCIATES

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO E-26-1-161 SHEET 2 OF 3

2

L A K E
W A S H I N G T O N
SEATTLE
City of Seattle
South Point
Coleman Point
42
43
44
45
46
47
48
49
50
51
53
54
60
61
62



LEGEND

SUB-BASIN BOUNDARY
EXISTING CHANNEL
EXISTING CONDUIT
MANHOLE, INLET, OR JUNCTION
CHANNEL OR CONDUIT DESIG. 5
CITY LIMITS
COUNTY (METRO) BOUNDARY
LEVEE

CULVERT
HOLDING POND OR LAKE

N

1/2 1/4 0 1
MILES
1000 500 0 4000
FEET

NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

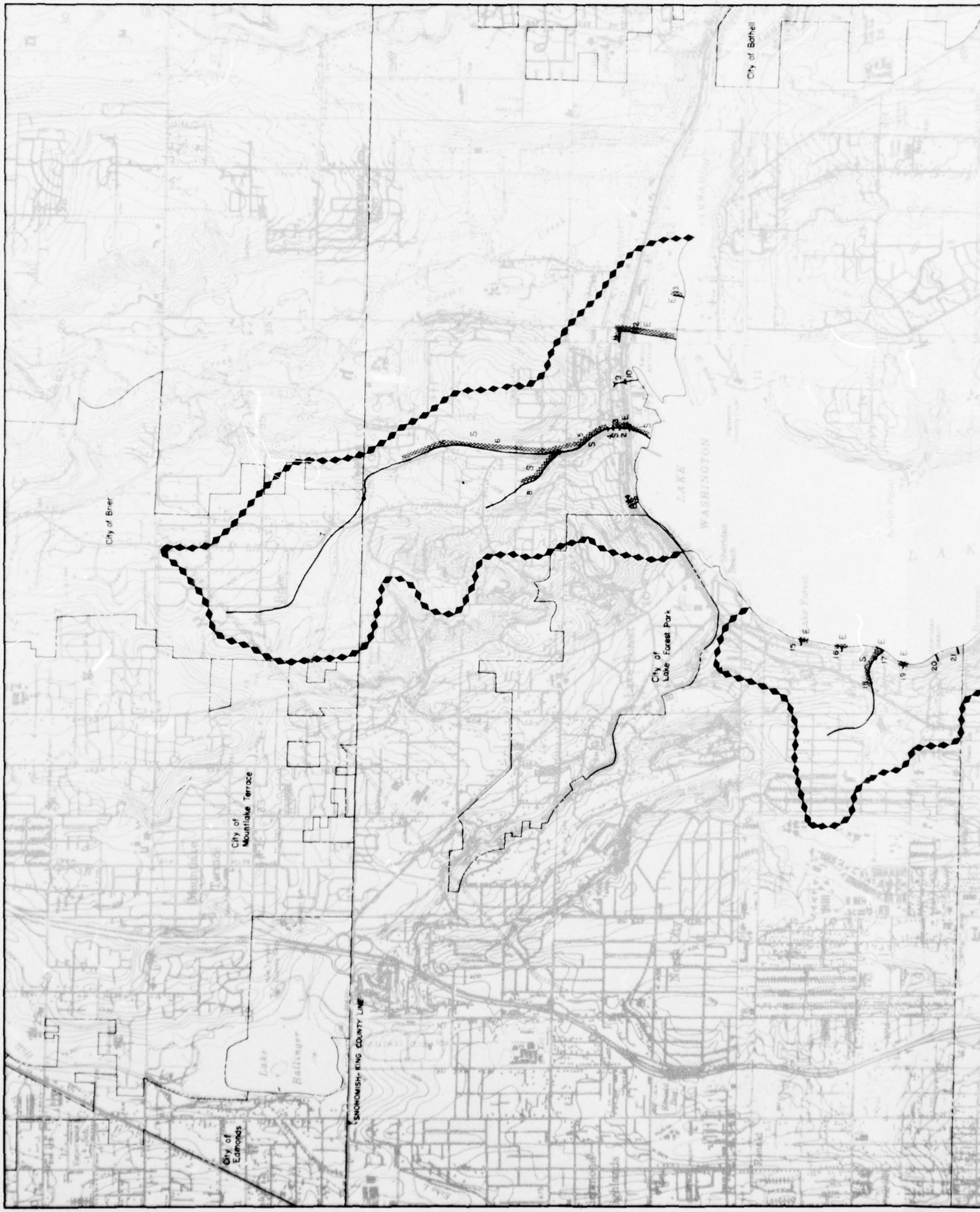
LAKE WASHINGTON WEST

PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

KRAMER, CHIN AND MAYO, INC.
WATER RESOURCES ENGINEERS, INC.
YODER, TROTTER, ORLOB & ASSOCIATES

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO. E-26-1-161 SHEET 3c OF 3



City of Bothell
City of Brier
City of Mountlake Terrace
City of Lake Forest Park
City of Edmonds
SNOHOMISH-KING COUNTY LINE
LAKE WASHINGTON
Lake Ballinger

LEGEND

SUB-BASIN BOUNDARY
EXISTING CHANNEL
EXISTING CONDUIT
MANHOLE, INLET, OR JUNCTION
CHANNEL OR CONDUIT DESIG
CITY LIMITS
COUNTY (METRO) BOUNDARY
LEVEE

CULVERT
HOLDING POND OR LAKE

MILES
FEET

NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

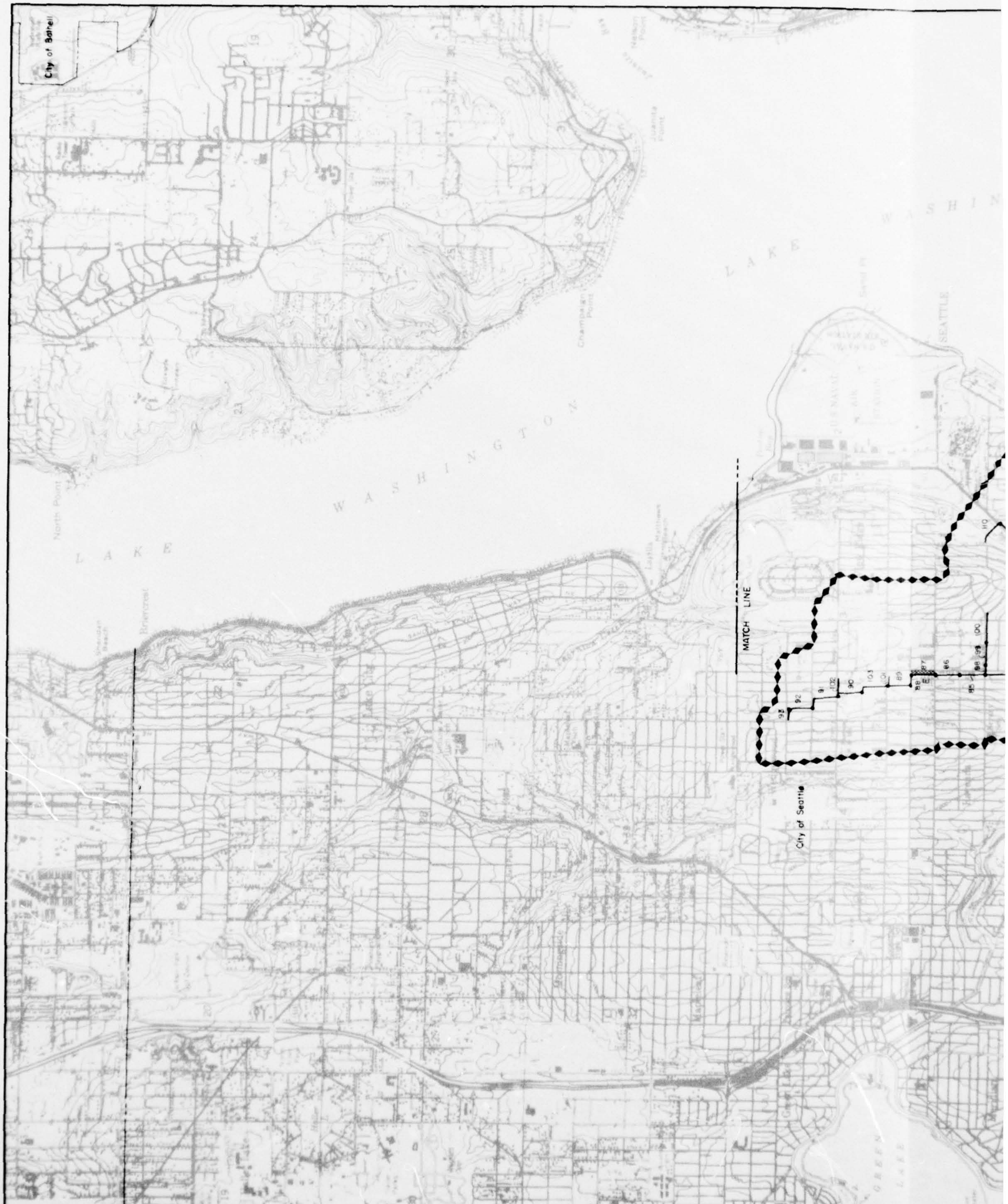
LAKE WASHINGTON WEST

PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

KRAMER, CHIN AND MAYO, INC
WATER RESOURCES ENGINEERS, INC
YODER, TROTTER, ORLOB & ASSOCIATES

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO E-26-1-161 SHEET 1a OF 3


City of Bothell
LAKE WASHINGTON
LAKE WASHINGTON
North Point
Juanita Point
Champagne Point
Sand Pt
U.S. NAVAL AIR STATION
SEATTLE
MATCH LINE
City of Seattle
GREEN LAKE

LEGEND

SUB-BASIN BOUNDARY
EXISTING CHANNEL
EXISTING CONDUIT
MANHOLE, INLET, OR JUNCTION
CHANNEL OR CONDUIT DESIG. 5
CITY LIMITS
COUNTY (METRO) BOUNDARY
LEVEE
CULVERT
HOLDING POND OR LAKE

N

1/2 1/4 0 1 MILES

1000 500 0 4000 FEET

NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

LAKE WASHINGTON WEST

PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

KRAMER, CHIN AND MAYO, INC
WATER RESOURCES ENGINEERS, INC
YODER, TROTTER, ORLOB & ASSOCIATES

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO E-26-1-161 SHEET 2 OF 3


LAKE WASHINGTON
SEATTLE
Bryn Mawr
City of Seattle

LEGEND

SUB-BASIN BOUNDARY
EXISTING CHANNEL
EXISTING CONDUIT
MANHOLE, INLET, OR JUNCTION
CHANNEL OR CONDUIT DESIG. 5
CITY LIMITS
COUNTY (METRO) BOUNDARY
LEVEE
CULVERT
HOLDING POND OR LAKE

N

1/2 1/4 0 1 MILES
1000 500 0 4000 FEET

NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

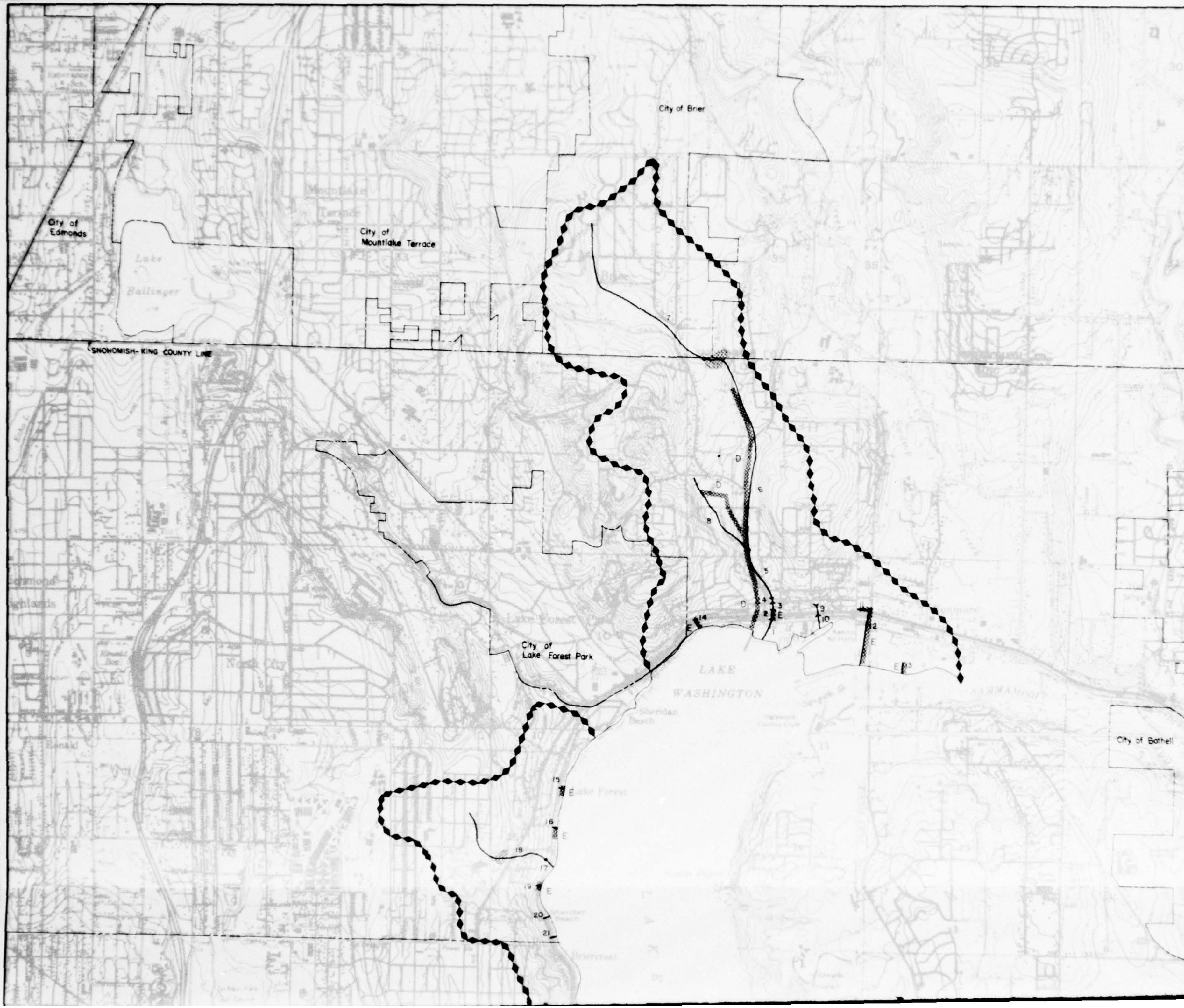
LAKE WASHINGTON WEST

PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

KRAMER, CHIN AND MAYO, INC.
WATER RESOURCES ENGINEERS, INC.
YODER, TROTTER, ORLOB & ASSOCIATES

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO. E-26-1-161 SHEET 3b OF 3


City of Brier
City of Edmonds
City of Mountlake Terrace
Lake Ballinger
SNOHOMISH - KING COUNTY LINE
City of Lake Forest Park
LAKE WASHINGTON
City of Bothell

LEGEND

SUB-BASIN BOUNDARY
EXISTING CHANNEL
EXISTING CONDUIT
MANHOLE, INLET, OR JUNCTION
CHANNEL OR CONDUIT DESIG
CITY LIMITS
COUNTY (METRO) BOUNDARY
LEVEE

CULVERT
HOLDING POND OR LAKE

N

1/2 1/4 0 1
MILES
1000 500 0 4000
FEET

NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

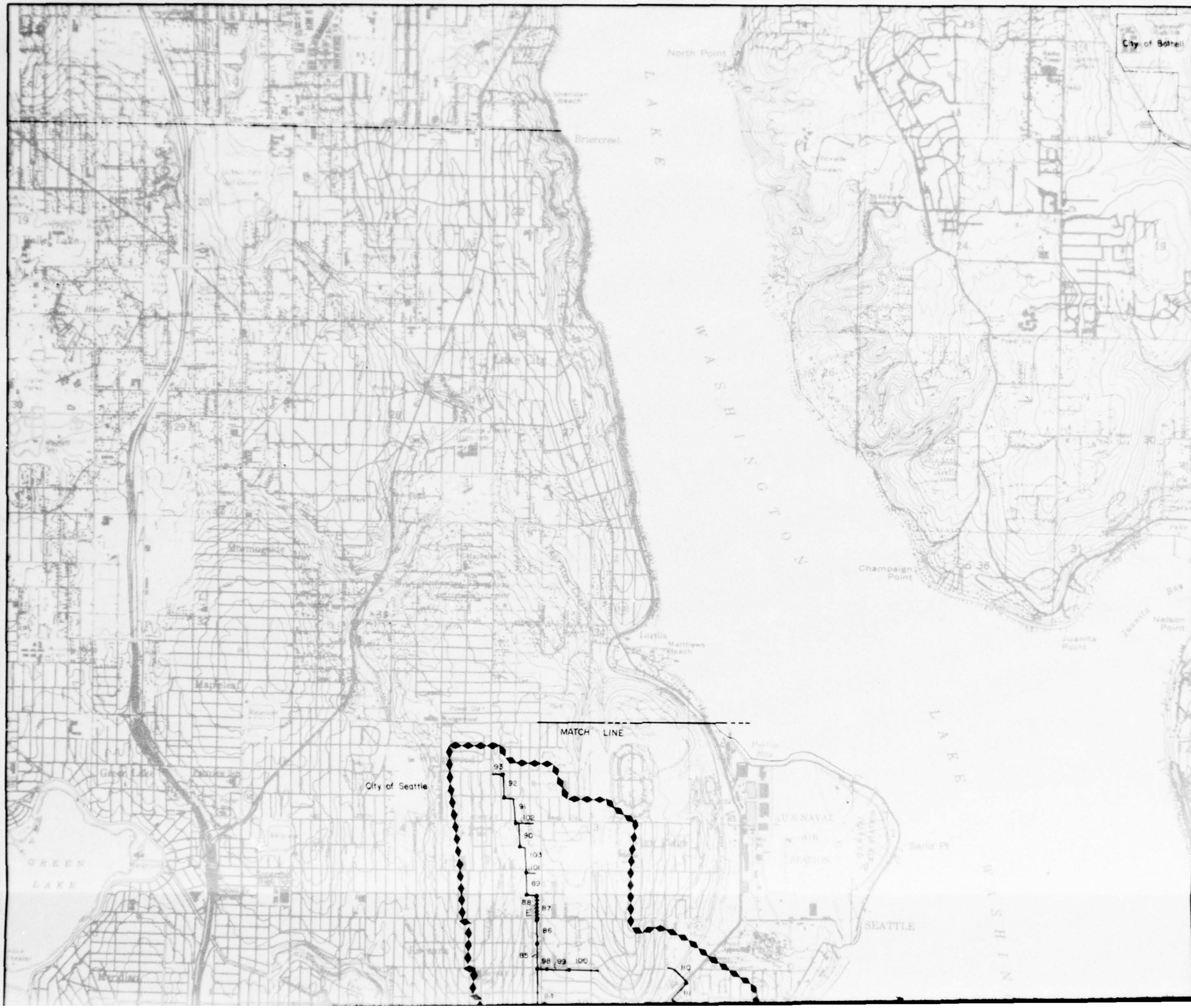
LAKE WASHINGTON WEST

PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

KRAMER, CHIN AND MAYO, INC
WATER RESOURCES ENGINEERS, INC
YODER, TROTTER, ORLOB & ASSOCIATES

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO E-26-1-161 SHEET 1C OF 3


City of Bothell
North Point
Sheridan Beach
Briercrest
LAKE WASHINGTON
Lake City
Champaign Point
Juanita Point
Juanita Bay
Nelson Point
Matthews Beach
MATCH LINE
City of Seattle
U S NAVAL AIR STATION
Sand Pt
SEATTLE
GREEN LAKE
93
92
91
102
90
103
101
89
88
87
86
85
98
99
100
110
111

LEGEND

SUB-BASIN BOUNDARY
EXISTING CHANNEL
EXISTING CONDUIT
MANHOLE, INLET, OR JUNCTION
CHANNEL OR CONDUIT DESIG. 5
CITY LIMITS
COUNTY (METRO) BOUNDARY
LEVEE

CULVERT
HOLDING POND OR LAKE

N

1/2 1/4 0 1
MILES
1000 500 0 4000
FEET

NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

LAKE WASHINGTON WEST

PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

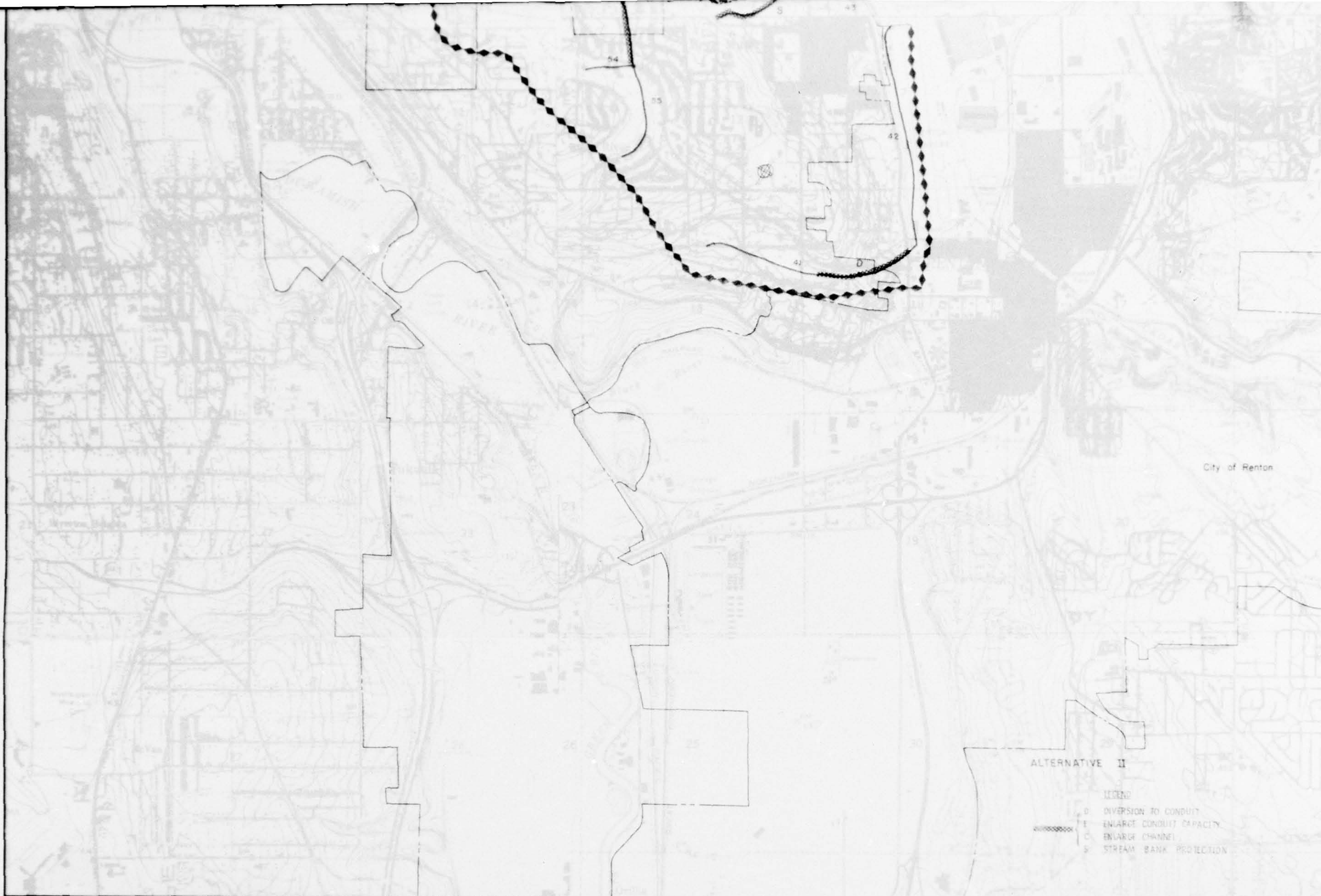
KRAMER, CHIN AND MAYO, INC.
WATER RESOURCES ENGINEERS, INC.
YODER, TROTTER, ORLOB & ASSOCIATES

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO E-26-1-161 SHEET 2E OF 3

2

City of Seattle
LAKE WASHINGTON
SEATTLE
Bryn Mawr
South Point
Coleman Point
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60
61
62
D
S



LEGEND

SUB-BASIN BOUNDARY
EXISTING CHANNEL
EXISTING CONDUIT
MANHOLE, INLET OR JUNCTION
CHANNEL OR CONDUIT DESIG
CITY LIMITS
COUNTY (METRO) BOUNDARY
LEVEE

CULVERT
HOLDING POND OR LAKE

N

MILES 1/2 1/4 0 1

FEET 1000 500 0 4000

NO.	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

LAKE WASHINGTON WEST

PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

KRAMER, CHIN AND MAYO, INC.
WATER RESOURCES ENGINEERS, INC.
YODER, TROTTER, ORLOB & ASSOCIATES

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO. E-26-1-161 SHEET 3C OF 3

REGIONAL SUB-BASIN C-13

THORNTON CREEK

NORTH FORK DEMONSTRATION AREA

GENERAL DESCRIPTION

The Thornton Creek Sub-Basin is located west of Lake Washington in North Seattle. It lies in a northwest/southwest orientation with the creek draining southeast into Lake Washington at Matthews Beach north of Sand Point. Geography of the sub-basin is generally moderate in the upland area, with several sections of gullies and hills. Total elevation change is from almost 500 ft. to 15 ft. above sea level at Lake Washington. The stream channel is contained in a restricted valley, but a narrow flood plain exists throughout most of its length. The City of Seattle controls approximately 70% of the sub-basin with the remainder being in King County.

The principal stream is Thornton Creek that consists of a North Fork and South (West) Fork. The North Fork, which extends for five and a half miles, first appears from a culvert north of Jackson Park Golf Course below Ronald Bog and the South Fork begins in the vicinity of 5th Ave. Northeast near the Northgate Shopping Mall and North Seattle Community College. The South Fork is presented in this Appendix as a regional sub-basin. The forks join at Meadowbrook Park on 35th Ave. N.E. The stream flows through developed residential areas and parklands and changes character numerous times as it is affected by abutting properties. Remnants of wetland areas can be seen above the North Fork at Ronald Bog and an unnamed area near N.E. 155th. Other small areas exist throughout the sub-basin.

Stream	Category	Drainage Area	Discharge
North Fork	III	6.9 sq. mi.	Thornton Creek (Meadowbrook Park)

Present development in the North Fork sub-area consists of extensive residential areas, major commercial centers and a highly developed transportation system that includes portions of Interstate 5 and Lake City Way plus other major local arterials. There are several major parks and institutional uses. The overall character of the sub-area is urban, with only 2% of the land now undeveloped.

PERCENT OF SUB-AREA IN SPECIFIED LAND USE

Land Use	Existing (1970-72)	P.S.G.C. Land Use Projection Comprehensive	Corridor
Single Family	79	77	72
Multiple Family	2	2	4
Commercial/Services	5	7	8
Govt. and Educ.	5	6	7
Industrial			
Parks/Dedicated Open Space	5	6	7
Agriculture			
Airports, Railyards, Freeways, Highways	2	2	2
Unused Land	2		
Water			
Total	100	100	100
Total Impervious Area	43	45	46

The development pattern of this sub-area is fixed and allows little latitude for addition or change as is seen in the P.S.G.C. land-use projections. The additions that will occur will be primarily in the commercial and multiple-family residential sector.

NATURE OF EXISTING DRAINAGE SYSTEM

The existing drainage system of the North Fork of Thornton Creek consists of several tributaries, many small gullies, and a partial system of storm drains, curbs, gutters, and culverts along the major arterials. Much of the sub-area is drained by open channels along the streets. Most of the stream has been modified to some extent. Much of the sub-area, although developed, does not have a storm-drain system and relies upon overland flows to streets and streamways. Street improvements in the sub-area have been delayed due to a lack of drainage facilities.

In a highly urbanized setting such as Seattle, those portions of the streamways that are accessible to the public are great amenities.

By the nature of existing development, it is unlikely that there will be an opportunity to create a continuous greenway and the stream will remain an amenity primarily to those with abutting property and in those stretches of existing public ownership.

The State Department of Game and Department of Fisheries believe that the stream is impassable to fish due to culverts in the lower reaches and therefore consider it an unproductive stream. Local residents, however, have reported spawning by anadromous fish, and there are local varieties of fish in the stream as well.

DRAINAGE PROBLEMS

The greatest problem in this sub-area is the high level of impervious area and runoff generated therefrom. Many local upland pockets are natural wetlands that have been developed without adequate drainage. The same problem exists on a number of local streets that have no planned drainage systems. Roadside ditches overflow on a regular basis and reports of basement flooding, street flooding, soggy ground, mildewed foundations and yard ponding are numerous and recurrent problems.

As in the case of many highly urbanized areas, the tremendous increase in runoff over what occurred naturally is much in excess of the capacity of Thornton Creek. These flows cause erosion, flooding, and structural damage to whatever lies in its path. The resultant effect upon the receiving water, Lake Washington, is evident by siltation at Matthews Beach where a delta has been formed. In addition, oil and debris is washed into the lake to degrade water quality and discourage fish propagation and other desirable biological productivity.

The results of hydrologic analysis indicate no significant difference between the Comprehensive and Corridor land-use plans. Therefore, the drainage alternatives presented herein are applicable to both plans. The percentage of impervious surface in the sub-area is projected to remain at approximately the same level in the year 2000 as exists today, 45%.

In the future, under both the Comprehensive and Corridor concepts of land use, the problem of erosion and creek flooding will become more severe. With more complete drainage of tributary properties, including residential and commercial land, flow rates in the creek will increase unless provisions are made on site to control flows or divert runoff from the main stream. Problems along Thornton Creek will be intensified as encroachment by local property owners continues, unless some form of drainage management is instituted in the sub-area.

Reported property damages obtained from local agencies placed the average annual loss for Thornton Creek sub-area at $10,250.

BASIC ISSUES AND STATUS OF DRAINAGE PLANNING

As part of the Public Involvement effort of the RIBCO Program, a "citizens packet" describing five engineering techniques was distributed to residents in the sub-area and comments about the alternatives were solicited. The five plans were:

1) Continuation of Present Trends

2) Storm Water Diversion Facilities

3) Flood-Plain Management

4) Channelization (enlarging Thornton Creek)

5) Watershed Management (control of upland development)

Of these choices, greatest support from those responding to the questionnaire, was given to the concept of on-site storage and use of holding ponds. The second, in order of preference, was the improvement of stream channels, followed by diversion of runoff directly to Lake Washington. The fourth, in order of preference, was storm sewers along all streets, and the least desirable was to do nothing at all.

The City of Seattle Engineering Department has plans for new conventional storm-drain trunk systems for the entire Thornton Creek sub-basin. This plan would require a large capital outlay and has not yet been funded. An interesting feature of one part of this plan is the proposed use of the old, abandoned sanitary sewer outfall to Lake Washington as a bypass, peak-flow storm drain. This is in use now and affords some added protection for the lower reaches of Thornton Creek. The City of Seattle Department of Parks and Recreation and King County have purchased a significant portion of the undeveloped stream-side and wetland properties and also operate several parks along the stream. The Thornton Basin Improvement Association is now involved in the definition of problems along Thornton Creek with the goal of creating a surface-water management policy for the sub-basin. The north fork of the stream has been designated as one of five demonstration areas in the RIBCO study and has received intensive analysis.

Staff members from the City of Seattle Engineering Department and representatives from the Thornton Basin Improvement Association have reviewed the initial alternative plans for drainage developed by this RIBCO study for the Thornton Creek North Fork sub-area.

ALTERNATIVE PLANS FOR PROPOSED DRAINAGE CONTROL

The existing Thornton Creek North Fork sub-area drainage system, as described by local agencies, was evaluated by computer simulation that applied the region's 10-year storm to P.S.G.C. year 2000 land use. Drainage problems thus identified were analyzed and possible solutions

were provided in development of alternative plans for drainage control as described below.

ALTERNATIVE PLAN I

General Concept

This alternative entails enlargement of natural channels, man-made channels, culverts, and storm sewers to allow uninterrupted flow for the length of Thornton Creek. It will involve considerable construction on the creek itself as well as placement of storm sewers in public right-of-ways to parallel existing, inadequately sized trunks. In essence, it consists of conventional storm-sewer construction, use of the existing natural stream where possible and the changing of it to a controlled open channel where necessary.

Major Features

The key element in this plan is the stream channel itself from Ronald Bog in the northwest corner, south to the confluence of the North Fork of Thornton Creek and Maple Leaf Creek, and beyond. The proposed improvements include widening of the stream, providing for greater capacity, rip-rapping embankments where it is necessary to prevent erosion, and paving of selected sections where there is insufficient room for an enlarged channel. In a number of areas, tributary to the creek, new storm sewers parallel to existing trunks and channels will be necessary to meet drainage needs.

This plan does not credit Ronald Bog or any of the existing wetland depressions in the sub-area with detention storage; when, in fact, they may continue to function as they do now in the capacity of limited runoff-control features. If these areas remain undeveloped, actual 10-year peak storm flows could be less than predicted.

Cost

The cost for Alternative Plan I is estimated to be $2,900,000.

ALTERNATIVE PLAN II

General Concept

To reduce flows in Thornton Creek and thereby somewhat limit the cause of erosion and need for channel improvements, it is possible to divert runoff through a major trunkline around the most heavily developed section, downstream of 15th Ave. N.E. This line would be constructed only as a diversion for peak runoff flows along existing public right-of-ways and would be designed to maintain low stream flows and summer base-flow conditions.

This concept does not provide for detention storage, so channel improvements similar to those described in Alternative Plan I would be required in all areas except that stretch of stream protected by the diversion facility.

The capacity of the diversion line could be great enough to limit peak flows in Thornton Creek to approximate natural variation, but for economic reasons, it is assumed that the Creek will be used to the maximum extent possible that is consistent with the objective of diverting damaging peak runoff. This will require channel improvements in some areas, but construction would be kept to a minimum.

Major Features

The most important item in this plan is a storm trunk line that ranges from 6 to 9 feet in diameter, which parallels Thornton Creek on the north side, from where it intersects 15th Ave. N.E. to the old Lake City Sewage Treatment Plant on 35th Ave. N.E. A diversion structure would be built at 15th Ave. N.E. to accommodate runoff from the areas north and west, and a second diversion line would be installed at the confluence of Maple Leaf Creek. The trunk line would have only limited access between these points; the majority of runoff generated in the areas through which it passes would then discharge to Thornton Creek as they have in the past. If flows are greater than anticipated in the future, connection can be made in selected locations to decrease the total stream flow.

Cost

The cost for Alternative Plan II is estimated to be $4,500,000.

ALTERNATIVE PLAN III

General Concept

The primary objective of this alternative is to retain water in large holding ponds and to control the rate at which it is released so that downstream channels and culverts can handle the flow. In all, six holding ponds have been located in the sub-area. In actual practice, there may be more ponds, depending upon available land and the expected effect such storage might have. In addition, this concept may be extended to apply to individual storage ponds on roof tops, parking lots and playfields, but for this alternative, large facilities only have been considered.

Major Features

The major features of this alternative are holding ponds in the following locations: 1) Ronald Bog, 2) the area adjacent to I-5 on the west side just north of Jackson Park Golf Course, 3) the south end of

Jackson Park Golf Course, 4) a proposed County Park north of the golf course off of N.E. 145th St., 5) a depression just south of Acacia Cemetery, and 6) embankment storage behind Lake City Way.

In addition, since flows in the future will still increase above their present values, some channel widening and culvert replacement will be necessary to accommodate runoff. This includes a number of storm trunk lines paralleling existing facilities.

Cost

The cost for Alternative Plan III is estimated to be $2,500,000.

ALTERNATIVE PLAN IV

General Concept

This alternative utilizes nine holding ponds in the Thornton Creek North Fork sub-area in order that stream channel improvements be further minimized from that presented in Alternative Plan III. For this reason, holding ponds were located not only in the upstream watersheds, but also directly adjacent to the creek in the lower reaches, thus minimizing the number of stream-channel improvements (i.e. riprapping, excavation, diversion conduits, etc.). Runoff control was used in this alternative in order to limit peak runoff rates.

Major Features

The most significant feature in this alternative is the use of nine holding ponds. The first holding pond retains all flow in "off-line storage", i.e. storage not directly on Thornton Creek that is in excess of the capacity of the pipe system. The second holding pond presently exists as the Ronald Bog. Parallel pipelines are required to allow upstream runoff to reach the Bog. The third holding pond will accommodate the additional runoff that presently causes the flooding near N.E. 145th and Interstate 5. The fourth holding pond is located on the main channel of Thornton Creek.

The remaining five holding ponds are all considered "off-line" storage. The parallel pipelines are required to route flow to and/or from the holding ponds.

There is a difference between "on-line" holding ponds and "off-line" holding ponds. In order to retain natural areas, and minimize construction and land acquisition costs, holding ponds were located, as much as possible, in natural wetlands. The on-line storage occurs in these wetlands (Ronald Bog, Jackson Park Golf Course), whereas off-line storage usually requires more land and more extensive facilities.

In regard to runoff control, King County presently has a storm-drainage policy for land development that states, "drainage plans shall provide storm water retention facilities so that peak discharge from the site will not be increased by more than 25% due to the proposed development."

Even with this policy, both holding ponds and parallel pipeline facilities (diversion pipelines) are required to prevent major flooding in the Thornton Creek sub-area.

Cost

The cost for Alternative Plan IV is estimated to be $3,500,000.

PEAK FLOW COMPARISONS

The following table indicates 10-year peak flows under existing facilities and land use and under alternate drainage management solutions for the year 2000.

COMPARISON OF 10-YEAR PEAK FLOWS
(Cubic Feet Per Second)

	Existing Land Use					
North Fork Location	Existing Facilities	Existing Facilities	Alt.Plan I	Alt.Plan II	Alt.Plan III	Alt.Plan IV
15th Ave. N.E.	140	155	680	150	370	230
35th Ave. N.E.	300	195	920	520	680	330
Maple Leaf Creek	40	45	160	180	90	10
Outlet; 39th Ave. N.E.	70	275	1780	Thornton Creek 250 Diversion Line 910	790	370

ENVIRONMENTAL ASSESSMENT OF ALTERNATIVE PLANS

Field inspections were made to judge the applicability of the suggested alternative plans for this sub-area. This process was followed throughout the RIBCO Study for development of alternative plans for the various regional sub-basins. The inspections were based upon the alternative evaluation procedure which identified 34 unique criteria grouped in general categories as follows: 1) Effectiveness, 2) Human Values, 3) Environmental Factors, 4) Implementation and 5) Resource Requirements. The various structural solutions were checked against the appropriate

criteria and the various non-structural solutions were reviewed for their relationship to existing and probable future developments. The criteria rating total for Alternative Plan I which employs stream bank protection, channelization and parallel conduit, was a minus 31 on a scale ranging from a positive 108 to negative 108. The total evaluation rating for Alternative Plan II, which employs stream bank protection, channelization, parallel conduit and diversion, was a minus 35. The total evaluation rating for Alternative Plan III, which involves stream bank protection, channelization, parallel conduit and storage, was a plus 16. The total evaluation rating for Alternative Plan IV, which employed storage, runoff control, diversion and some enlarged conduit, was a plus 21.

Alternative Plans I, III and IV received positive ratings for effectiveness and all plans were judged to be effective for flood-damage reduction. Because of the diversion system, Alternative Plan II was low-rated on reliability, maintainability and flexibility. Only Alternative Plan III received a positive rating for promotion of human values, as it did not require displacement of people and was viewed to have certain educational value. Alternative Plan IV does require acquisition of areas now developed for residences or commercial use, to provide the necessary holding ponds suggested in this system. The extensive channelization involved in Alternative Plan I and II was felt to negatively affect the aesthetic quality of Thornton Creek's North Fork.

Alternative Plans III and IV both received positive ratings for environmental factors as they employ storage that should aid water quality and assure low-flow conditions. In addition, Alternative Plan IV requires little alteration of the natural stream. Alternative Plans I and II were judged to be detrimental to wildlife and vegetation as well as negatively affecting aquatic life. Both the latter alternatives require extensive alteration of the natural system. All four alternative plans are judged equally difficult to implement partially because of the two jurisdictions involved and because all plans rely upon land acquisition which is judged to be difficult to accomplish in a developed area. Alternative Plans III and IV are based upon the concepts which have been promoted by residents along the North Fork, but they must be accomplished in the immediate future before it is necessary to channelize or line the remainder of the North Fork of Thornton Creek. All four alternative plans were judged to be consumptive of resources. Alternative Plans I and II received the maximum negative total in this category. Alternative Plan III has the only land requirements that would have some multiple-use potential, although it is not felt to be significant. All four alternative plans require high capital outlays to accomplish their suggested systems.

A critical element in both Alternative Plans III and IV is the proposal to use natural storage areas that exist at this time within the sub-area. This treatment, if it is to be part of the chosen alternative, should be implemented as an early organized effort of the involved

agencies. The development or removal of these storage areas will force the use of more complex drainage control features than either Alternative Plan III or IV contemplates. Alternative Plan IV, in addition, relies upon control of runoff from new development that is limited to 25% over existing conditions. This feature will have little impact upon runoff control within the North Fork sub-area as development is not expected to increase significantly in the future. Alternative Plan IV also contemplates the purchase of upland homes to prevent flooding along portions of the North Fork, or to alleviate the need for channelization or enlargement of existing facilities. The cost of this suggestion is questionable as is the actual benefit received. A possible alternative to this portion of Alternative Plan IV, would be the acquisition of those homes which experience flooding problems along Thornton Creek and the designation of lands so acquired as flood-plain zones thereafter.

CONCLUSIONS

Alternative Plans III and IV are judged to be superior to both Alternative Plans I and II because the use of upstream storage within the North Fork sub-area would result in the least alteration of the natural stream. The concepts set forth in Alternative Plans III and IV should promote water quality as well as assure low-flow conditions within Thornton Creek.

King County and the City of Seattle should establish an effective agreement for a master drainage plan that incorporates the provisions of Alternative Plans III or IV. The two agencies involved should then move to acquire the necessary storage areas within their own jurisdictions. The City of Seattle should have primary responsibility for control of drainage and flood damage within the North Fork sub-area, and King County should exercise necessary authority within its boundaries.

EARLY ACTION

In addition to the immediate need for development of a drainage master plan and designation of jurisdictional leadership within this demonstration area, certain physical features of the alternative plans, presented herein, appear to be generally applicable to any drainage plan which may be forthcoming as well as both suitable and desirable for early implementation within the next 10-year period. These features are presented in the three categories previously defined.

FACILITY RECOMMENDATIONS

The basic recommendations for Thornton Creek are preservation of the natural drainage system and alleviation of severe flooding problems.

In regard to the North Fork of Thornton Creek, many propertyowners have blocked or restricted the Creek with fences, walls, foot-

bridges, etc. These constraints should be removed to the point that the resulting creek cross-section will be uniform.

Prior to making a decision as to an alternative drainage plan for the Thornton Creek Demonstration Area, design and construction could proceed for all or some of the following elements:

Category I - Common Alternative Elements

Element Number	Proposed Facility	Estimated Capital Cost
60	24" pipe - 3200'	$131,000
133	27" pipe - 1000'	47,000
	TOTAL	$178,000

Category II - Alternative Elements Common in Scope

Element Number	Proposed Facility
95	holding pond
104	Ronald Bog
41	48" pipe to lined channel
43	48" pipe to lined channel
44	27" to 48" pipe
46	27" to 42" pipe
48	21" to 42" pipe
50	24" to 42" pipe
79	18" to 27" pipe
83	36" pipe to channel
97	48" to 72" pipe
98	24" to 78" pipe
99	24" to 66" pipe
136	24" to 48" pipe
138	24" to 60" pipe

Category III - Response to Reported Drainage Problems

None in addition to those in Categories I and II.

EVALUATION MATRIX

THORNTON CREEK DEMONSTRATION AREA

ALTERNATIVES	SUB TOTAL	EFFECTIVENESS: Use of existing facilities	System reliability	System maintainability	System flexibility	Flood damage reduction	Consequences of overcharge	Erosion and sedimentation control	Cost/benefits ranking
		CRITERIA WEIGHT 1	4	3	2	4	4	4	2
I	+3	-1 -1	+1 +4	0	-1 -2	+1 +4	0	0	-1 -2
II	-1	-1 -1	0	0	-1 -2	+1 +4	0	0	-1 -2
III	+12	0	+1 +4	0	0	+1 +4	0	+1 +4	0
IV	+13	+1 +1	+1 +4	0	+1 +2	+1 +4	0	+1 +4	-1 -2

ALTERNATIVES	SUB TOTAL	HUMAN VALUES: Urban quality (aesthetics)	Effect on land use	Displacement of people	Educational value	Community cohesion	Multiple use potential	Public health and safety
		CRITERIA WEIGHT 4	2	2	1	3	3	4
I	-3	-1 -4	+1 +2	+1 +2	0	0	-1 -3	0
II	-3	-1 -4	+1 +2	+1 +2	0	0	-1 -3	0
III	+1	0	-1 -2	+1 +2	+1 +1	0	0	0
IV	-1	0	0	-1 -2	+1 +1	0	0	0

ALTERNATIVES	SUB TOTAL	ENVIRONMENTAL FACTORS: High flow conditions	Alteration of natural system	Effects on groundwater	Low flow conditions	Water quality	Construction disruption	Effects on wildlife	Effects on aquatic life	Effects on vegetation
		CRITERIA WEIGHT 4	4	4	4	4	2	4	4	4
I	-14	0	-1 -4	0	0	0	-1 -2	-1 -4	0	-1 -4
II	-18	0	-1 -4	0	0	0	-1 -2	-1 -4	-1 -4	-1 -4
III	+8	+1 +4	-1 -4	+1 +4	+1 +4	+1 +4	0	0	-1 -4	0
IV	+18	+1 +4	+1 +4	+1 +4	+1 +4	+1 +4	-1 -2	0	0	0

ALTERNATIVES	SUB TOTAL	IMPLEMENTATION: Legislative requirements	Jurisdictional	Land acquisition	Public acceptance	Financing	Effects of no action
		CRITERIA WEIGHT 4	4	2	4	4	3
I	-7	0	-1 -4	-1 -2	-1 -4	0	+1 +3
II	-3	0	-1 -4	-1 -2	0	0	+1 +3
III	-5	0	-1 -4	-1 -2	+1 +4	0	-1 -3
IV	-5	0	-1 -4	-1 -2	+1 +4	0	-1 -3

ALTERNATIVES	SUB TOTAL	RESOURCE REQUIREMENTS: Energy	Materials	Land	Capital	RATING TOTAL
		CRITERIA WEIGHT 3	3	2	2	
I	-10	-1 -3	-1 -3	-1 -2	-1 -2	-31
II	-10	-1 -3	-1 -3	-1 -2	-1 -2	-35
III	0	0	0	+1 +2	-1 -2	+16
IV	-4	0	0	-1 -2	-1 -2	+21

RUNOFF QUALITY SUMMARY
THORNTON CREEK DEMONSTRATION AREA

BASED UPON A 10-YEAR STORM PRECEDED BY 5 DAYS WITH LITTLE OR NO RAINFALL#

LOCATION	ALTERNATIVE PLAN	PEAK FLOW (cfs)	CONCENTRATION AT PEAK FLOW*				
			BOD	TOTAL COLIFORM	NH_3	$NO_2 + NO_3$	PO_4
N.E. 158th St. and Interstate 5	Present	150	3	5.7×10^4	.1	.2	.1
	I	470	3	5.0×10^4	.1	.2	.1
	II	470	3	5.0×10^4	.1	.2	.1
	III	330	3	6.9×10^4	.1	.2	.1
	IV	150	3	5.3×10^4	.1	.2	.1
15th Ave. N.E. and N.E. 130th Place	Present	140	4	6.0×10^4	.1	.3	.1
	I	680	5	1.2×10^4	.1	.4	.1
	II	150	3	5.0×10^5	.1	.2	.1
	III	370	6	1.5×10^5	.2	.4	.1
	IV	270	4	5.4×10^4	.1	.2	.1

Less than a total of 0.5 inches of rainfall in any one day.
* Concentrations in mg/liter except total coliform which is in MPN/100 ml.

RUNOFF QUALITY SUMMARY
THORNTON CREEK DEMONSTRATION AREA

BASED UPON A 10-YEAR STORM PRECEDED BY 5 DAYS WITH LITTLE OR NO RAINFALL#

LOCATION	ALTERNATIVE PLAN	PEAK FLOW (cfs)	CONCENTRATION AT PEAK FLOW*				
			BOD	TOTAL COLIFORM	NH_3	$NO_2 + NO_3$	PO_4
Outlet @ demo area boundary							
39th Ave. N.E. and N.E. 107th St.	Present	70	12	1.1×10^5	.3	.8	.1
	I	1070	7	1.5×10^5	.2	.5	.1
	II	250	4	4.0×10^4	.1	.3	.1
	III	790	6	1.5×10^5	.2	.5	.1
	IV	370	4	6.0×10^4	.1	.3	.1

Less than a total of 0.5 inches of rainfall in any one day.
* Concentrations in mg/liter except total coliform which is in MPN/100 ml.

RUNOFF QUALITY SUMMARY
THORNTON CREEK DEMONSTRATION AREA

BASED UPON A 10-YEAR STORM PRECEDED BY 15 DAYS WITH LITTLE OR NO RAINFALL#

LOCATION	ALTERNATIVE PLAN	PEAK FLOW (cfs)	CONCENTRATION AT PEAK FLOW*				
			BOD	TOTAL COLIFORM	NH_3	$NO_2 + NO_3$	PO_4
N.E. 158th St. and Interstate 5	Present	150	9	1.7×10^5	.2	.6	.1
	I	470	8	1.5×10^5	.1	.5	.1
	II	470	8	1.5×10^5	.1	.5	.1
	III	330	10	2.1×10^5	.2	.7	.1
	IV	150	8	1.6×10^5	.2	.6	.1
15th Ave. N.E. and N.E. 130th Place	Present	140	12	1.8×10^5	.2	.8	.1
	I	680	16	3.6×10^5	.4	1.1	.1
	II	150	8	1.5×10^5	.1	.5	.1
	III	370	17	4.6×10^5	.5	1.3	.1
	IV	230	10	1.6×10^5	.2	.7	.1

Less than a total of 0.5 inches of rainfall in any one day.
* Concentrations in mg/liter except total coliform which is in MPN/100 ml.

RUNOFF QUALITY SUMMARY
THORNTON CREEK DEMONSTRATION AREA

BASED UPON A 10-YEAR STORM PRECEDED BY 15 DAYS WITH LITTLE OR NO RAINFALL#

LOCATION	ALTERNATIVE PLAN	PEAK FLOW (cfs)	CONCENTRATION AT PEAK FLOW*				
			BOD	TOTAL COLIFORM	NH_3	$NO_2 + NO_3$	PO_4
Outlet @ demo area boundary							
39th Avenue N.E. and N.E. 107th St.	Present	70	43	3.7×10^5	1.0	2.8	.3
	I	1070	22	4.9×10^5	.6	1.6	.2
	II	250	13	1.2×10^5	.3	.9	.1
	III	790	19	4.4×10^5	.5	1.4	.1
	IV	370	12	1.8×10^5	.2	.8	.1

Less than a total of 0.5 inches of rainfall in any one day.
* Concentrations in mg/liter except total coliform which is in MPN/100 ml.

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative I Sub-Basin Thornton Creek Demonstration Area

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
128	Pipe	18"	1,300'			Parallel Pipe	30"	$69,000
127	Pipe	18"	800'			Parallel Pipe	42"	$63,000
126	Pipe	24"	800'			Parallel Pipe	42"	$63,000
125	Pipe	30"	1,000'			Parallel Pipe	42"	$79,000
106	Pipe	42"	500'			Parallel Pipe	60"	$59,000
139	Pipe	18"	1,000'			Parallel Pipe	60"	$119,000
105	Pipe	24"	1,500'			Parallel Pipe	42"	$118,000
99	Pipe	36"	200'			Parallel Pipe	66"	$27,000
138	Pipe	36"	1,300'			Parallel Pipe	60"	$154,000
98	Conc. Channel	3.5'	600'	0	1.5'	Replacement Pipe	78"	$98,000
97	Pipe	24"	60'			Parallel Pipe	72"	$9,000
96	Conc. Channel	4'	700'	1:1	1.5'	Replacement Pipe	78"	$114,000
89	Culvert	4'	40'	0	3.5'	Parallel Pipe	21"	$1,000
123	Pipe	18"	1,400'			Parallel Pipe	27"	$66,000
137	Pipe	33"	1,000'			Parallel Pipe	27"	$47,000
79	Pipe	30"	1,500'			Parallel Pipe	27"	$71,000
78	Culvert	6'	60'	0	1'	Parallel Culvert	78"	$22,000

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative I Sub-Basin Thornton Creek Demonstration Area

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
76	Pipe	48"	40'			Parallel Pipe	84"	$21,000
133	Pipe	30"	1,000'			Parallel Pipe	27"	$47,000
86	Pipe	30"	3,600'			Parallel Pipe	24"	$147,000
72	Culvert	6'	60'	0	4'	Parallel Box Culvert	12' X 4'	$23,000
42	Culvert	18'	40'	0	3'	Enlarged Culvert	30' X 3'	$20,000
70	Culvert	4.5'	40'	0	4'	Enlarged Culvert	12' X 4'	$15,000
65	Culvert	6'	100'	0	5'	Enlarged Culvert	9' X 5'	$21,000
57	Culvert	15"	60'			Parallel Culvert	42"	$5,000
61	Culvert	7'	60'	0	4.5'	Enlarged Culvert	13' X 4.5'	$20,000
56	Culvert	24"	100'			Parallel Culvert	36"	$7,000
60	Pipe	15"	3200'			Parallel Pipe	24"	$131,000
50	Culvert	24"	40'			Parallel Culvert	42"	$3,000
48	Culvert	24"	40'			Parallel Culvert	42"	$3,000
46	Culvert	24"	40'			Parallel Culvert	42"	$3,000
45	Channel	1.5' X 5'	1,300'			Parallel Pipe	36"	$85,000
44	Culvert	24"	40'			Parallel Culvert	48"	$4,000
40	Culvert	10'	40'	0	5'	Parallel Culvert	15' X 5'	$15,000

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative I　　Sub Basin Thornton Creek Demonstration Area

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
107	Pipe	42"	200'			Parallel Pipe	54"	$21,000
136	Pipe	12"	3,000'			Parallel Pipe	24"	$123,000
103	Channel	2.5'	1,000'	3:1	3'	Channel	12' width 3.5' depth 2:1 side slopes	$13,000
94	Channel	6'	500'	1:1	5'	Channel	6.5 width 5' depth 2:1 side slopes	$9,000
88	Channel	11.5'	250'	1:1	5'	Channel	15' width 2.7' depth 2:1 side slopes Bank protection	$15,000
83	Channel	15'	1,100'	2:1	1.5'	Channel	20' width 3.25' depth 2:1 side slopes Bank protection	$41,000
77	Channel	8'	1,200'	1:1	2.5'	Channel	20' width 3.5' depth 2:1 side slopes	$45,000
134	Channel	5'	300'	1:1	3'	Channel	20' width 4.2' depth 2:1 side slopes	$15,000
75	Channel	4.5'	1,600'	1:1	3'	Channel	20' width 4.25' depth 2:1 side slopes	$80,000
71	Channel	18'	500'	1:1	3.5'	Channel	20' width 2' depth 2:1 side slopes	$16,000
69	Channel	15'	1,500'	1:1	4'	Channel	16' width 4' depth 2:1 side slopes Bank protection	$71,000
64	Channel	10'	1,200'	1:1	3'	Channel	20' width 5' depth 2:1 side slopes Including bank protection	$101,000
59	Rectang. Concrete Channel	2.5'	2,600'		1'	Rectang. Conc. Channel	6' X 1'	$147,000
62	Rectang. Concrete Channel	6'	300'		4'	Rectang. Conc. Channel	16' width 4' depth	$54,000
57	Channel	3'	1,000'	1:1	1.5'	Channel	10' width 1.5' depth 2:1 side slopes	$25,000
55	Channel	3'	600'	1:1	3'	Channel	3' width 3' depth 2:1 side slopes	$9,000
43	Channel	5'	600'	1:1	2'	Paved Channel	20' width 3.5' depth 2:1 side slopes	$73,000

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative I Sub-Basin Thornton Creek Demonstration Area

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
41	Channel	10'	600'	2:1	2.5	Paved Channel	20' width 3.5' depth 2:1 side slopes	$63,000
49	Channel	10'	300'	2:1	1.5'	Channel	14' width 1.5 depth 2.1 side slopes	$2,000
39	Rectang. Conc. Channel	10'	600'		4'	Rectang. Conc. Channel	20' width 4' depth	$48,000
						Inlet and Outlet Struct.	20 culverts	$157,000

The Estimated Capital Cost for each element includes Contractor profit, engineering, legal and contingencies. In addition, land purchase and severance costs are included where land is required. All costs are based upon June 1973 prices.

Total Estimated Capital Cost: $2,877,000

Round To: $2,900,000

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative II   Sub Basin Thornton Creek Demonstration Area

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
128	Pipe	18"	1,300'			Parallel Pipe	30"	$69,000
127	Pipe	18"	800'			Parallel Pipe	42"	$63,000
126	Pipe	24"	800'			Parallel Pipe	42"	$63,000
125	Pipe	30"	1,000'			Parallel Pipe	42"	$79,000
106	Pipe	42"	500'			Parallel Pipe	60"	$59,000
139	Pipe	18"	1,000'			Parallel Pipe	60"	$119,000
105	Pipe	24"	1,500'			Parallel Pipe	42"	$118,000
99	Pipe	36"	200'			Parallel Pipe	66"	$27,000
138	Pipe	36"	1,300'			Parallel Pipe	60"	$154,000
98	Conc. Channel	3.5' X 1.5'	600'		1.3'	Replace-ment Pipe	78"	$98,000
97	Pipe	24"	60'			Parallel Pipe	72"	$9,000
96	Conc. Channel	4' X 1.5'	700'	1:1	1:5'	Replace ment Pipe	78"	$114,000
89	Culvert	4'	40'	0	3.5'	Parallel Pipe	21"	$1,000
123	Pipe	18"	1,400'			Parallel Pipe	27"	$66,000
137	Pipe	33"	1,000'			Parallel Pipe	27"	$47,000
79	Pipe	30"	1,500'			Parallel Pipe	27"	$71,000
133	Pipe	30"	1,000'			Parallel Pipe	27"	$47,000

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative II Sub Basin Thornton Creek Demonstration Area

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
86	Pipe	30"	3,600'			Parallel Pipe	24"	$147,000
201	None					Diversion Pipe	108" 3,000'	$721,000
202	None					Diversion Pipe	84" 1,500'	$266,000
203	None					Diversion Pipe	84" 3,300'	$585,000
56	Culvert	24"	100'			Parallel Culvert	36"	$7,000
60	Pipe	15"	3,200'			Parallel Pipe	24"	$131,000
50	Culvert	24"	40'			Parallel Culvert	42"	$3,000
48	Culvert	24"	40'			Parallel Culvert	42"	$3,000
46	Culvert	24"	40'			Parallel Culvert	42"	$3,000
45	Channel	1.5' X 5'	1,300'			Parallel Pipe	36"	$85,000
44	Culvert	24"	40'			Parallel Culvert	48"	$4,000
78	Culvert	6'	60'	0	1'	Parallel Culvert	54"	$6,000
76	Pipe	48"	40'			Parallel Culvert	54"	$4,000
72	Culvert	6'	60'	0	4'	Enlarged Box Culvert	7' X 4'	$10,000
70	Culvert	4.5'	40'	0	4'	Enlarged Box Culvert	7' X 4'	$7,000
61	Culvert	7'	60'	0	4.5'	Enlarged Box Culvert	8' X 4.5'	$8,000
107	Pipe	42"	200'			Parallel Pipe	54"	$21,000

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative II Sub Basin Thornton Creek Demonstration Area

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
136	Pipe	12"	3,000'			Parallel Pipe	24"	$123,000
67	Culvert	15"	60'			Parallel Culvert	42"	$5,000
204	None					Diversion Pipe	74" 1,300'	$198,000
205	None					Diversion Pipe	108' 2,000'	$481,000
77	Channel	8'	1,200'	1:1	2.5'	Channel	12' width 2.5' depth 2:1 side slopes	$16,000
134	Channel	5'	300'	1:1	3'	Channel	11' width 3' depth 2:1 side slopes	$6,000
75	Channel	4.5'	1,600'	1:1	3'	Channel	12' width 3.5' depth 2:1 side slopes	$42,000
69	Channel	15'	1,500'	1:1	4'	Channel	Bank protection only	$27,000
64	Channel	10'	1,200'	1:1	3'	Channel	18' width 4' depth 2:1 side slopes	$40,000
62	Rectang. Conc. Channel	6'	300'		4'	Rectang. Conc. Channel	10' width 4' depth	$14,000
59	Rectang. Conc. Channel	2.5'	2,600'		1'	Rectang. Conc. Channel	6' width 1' depth	$57,000
43	Channel	5'	600'	1:1	3'	Channel	12' width 3' depth 2:1 side slopes	$15,000
41	Channel	10'	600'	2:1	2.5'	Channel	12' width 3' depth 2:1 side slopes	$5,000
103	Channel	2.5'	1,000'	3:1	3'	Channel	12' width 3.5' depth 2:1 side slopes	$13,000
94	Channel	6'	500'	1:1	5'	Channel	6.5' width 5' depth 2:1 side slopes	$7,000
88	Channel	11.5'	250'	1:1	2.7'	Channel	15' width 2.7' depth 2:1 side slopes including bank protection	$37,000
83	Channel	15'	1,100'	2:1	1.5'	Channel	20' width 3.25' depth 2:1 side slopes including bank protection	$41,000

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative II   Sub Basin Thornton Creek Demonstration Area

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
55	Channel	3'	600'	1:1	3'	Channel	3' width 3' depth 2:1 side slopes	$9,000
57	Channel	3'	1,000'	1:1	1.5'	Channel	10' width 1.5' depth 2:1 side slopes	$25,000
49	Channel	10'	300'	2:1	1.5'	Channel	14' width 1.5' depth 2:1 side slopes	$2,000
						Inlet and Outlet Struc.	17 culverts	$115,000

The Estimated Capital Cost for each element includes Contractor profit, engineering, legal and contingencies. In addition, land purchase and severance costs are included where land is required. All costs are based upon June 1973 prices.

Total Estimated Capital Cost: **$4,493,000**

Round To: **$4,500,000**

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative III   Sub-Basin Thornton Creek Demonstration Area

ELEMENT NUMBER	EXISTING FACILITIES: TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	PROPOSED FACILITIES: TYPE		ESTIMATED CAPITAL COST
128	Pipe	18"	1,300'			Parallel Pipe	30"	$69,000
127	Pipe	18"	800'			Parallel Pipe	42"	$63,000
126	Pipe	24"	800'			Parallel Pipe	42"	$63,000
125	Pipe	30"	1,000'			Parallel Pipe	42"	$77,000
106	Pipe	42"	500'			Parallel Pipe	60"	$59,000
139	Pipe	18"	1,000'			Parallel Pipe	60"	$119,000
105	Pipe	24"	1,500'			Parallel Pipe	42"	$118,000
99	Pipe	36"	200'			Parallel Pipe	30"	$11,000
138	Pipe	36"	1,300'			Parallel Pipe	30"	$69,000
96	Conc. Channel	4' X 1.5'	700'	1:1	1.5'	Replacement Pipe	54"	$74,000
97	Pipe	24"	60'			Parallel Pipe	54"	$6,000
98	Conc. Channel	3.5' X 1.5'	600'			Replacement Pipe	54"	$63,000
89	Culvert	4'	40'	0	3.5'	Enlarged Culvert	6' X 3.5'	$5,000
123	Pipe	18"	1,400'			Parallel Pipe	21"	$50,000
137	Pipe	33"	1,000'			Parallel Pipe	15"	$25,000
79	Pipe	30"	1,500'			Parallel Pipe	18"	$46,000
78	Culvert	6'	60'	0	1'	Parallel Pipe	48"	$6,000

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative III Sub Basin Thornton Creek Demonstration Area

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
76	Pipe	48"	40'			Parallel Pipe	42"	$3,000
72	Culvert	6'	60'	0	4'	Enlarged Box Culvert	6.5' X 4'	$10,000
70	Culvert	4.5'	40'	0	4'	Enlarged Box Culvert	6.5' X 4'	$10,000
61	Culvert	7'	60'	0	4.5'	Enlarged Box Culvert	8' X 4.5'	$8,000
67	Culvert	15"	60'			Parallel Culvert	42"	$5,000
133	Pipe	30"	1,000'			Parallel Pipe	27"	$47,000
86	Pipe	30"	3,600'			Parallel Pipe	24"	$147,000
50	Culvert	24"	40'			Parallel Culvert	24"	$2,000
60	Pipe	15"	3,200'			Parallel Pipe	24"	$131,000
48	Culvert	24"	40'	1:1	1.5'	Parallel Pipe	21"	$1,000
46	Culvert	24"	40'	1:1	1:5	Parallel Pipe	27"	$2,000
44	Culvert	24"	40'			Parallel Culvert	27"	$2,000
136	Pipe	12"	3,000'			Parallel Pipe	24"	$123,000
88	Channel	11.5'	250'	1:1	5'	Channel	16' width 2' depth 2:1 side slopes including bank protection	$15,000
83	Channel	15'	1,100'	2:1	1.5'	Channel	16' width 2' depth 2:1 side slopes	$7,000
77	Channel	8'	1,200'	1:1	2.5'	Channel	9' width 2.5' depth 2:1 side slopes	$10,000
134	Channel	5'	300'	1:1	3'	Channel	8' width 3' depth 2:1 side slopes	$4,000

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative III Sub Basin Thornton Creek Demonstration Area

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
75	Channel	4.5'	1,600'	1:1	3'	Channel	14' width 3' depth 2:1 side slopes	$39,000
69	Channel	15'	1,500'	1:1	4'	Channel	Bank protection only	$24,000
64	Channel	10'	1,200'	1:1	3'	Channel	Bank protection only	$60,000
62	Rectang. Conc. Channel	6'	300'		4'	Rectang. Conc. Channel	10' width 4' depth	$14,000
57	Channel	3'	1,000'	1:1	1.5'	Channel	8' width 1.5' depth 2:1 side slopes	$10,000
49	Channel	10'	300'	2:1	1.5'	Channel	14' width 1.5' depth 2:1 side slopes	$2,000
43	Channel	5'	600'	1:1	2'	Paved Channel	14' width 3' depth 2:1 side slopes	$53,000
41	Channel	10'	600'	2:1	2.5'	Rectang. Conc. Channel	14' width 3' depth	$27,000
39	Rectang. Conc. Channel	10'	600'		4'	Rectang. Conc. Channel	11' width 4' depth	$26,000
						Inlet and Outlet Struc.	18 culverts	$86,000
104		Ronald Bog (Natural Retention Only)				Holding Pond	17.5 AF	$180,000
95		(Existing Pond (Natural Retention Only)				Holding Pond	7.80 AF	$172,000
151		Jackson Park Golf Course				Holding Pond	27.5 AF	$37,000
152	None	(Potential County Park Site)				Holding Pond	4 AF	$11,000
153	None					Holding Pond	2.8 AF	$127,000
155	None					Holding Pond	2.3 AF	$195,000

The Estimated Capital Cost for each element includes Contractor profit, engineering, legal and contingencies. In addition, land purchase and severance costs are included where land is required. All costs are based upon June 1973 prices.

Total Estimated Capital Cost: $2,513,000
Round To: $2,500,000

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative IV Sub-Basin Thornton Creek Demonstration Area

	EXISTING FACILITIES					PROPOSED FACILITIES		
ELEMENT NUMBER	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
104	Ronald Bog					Holding Pond	13 AF 13 acres Pump	$48,000
95	Small lake with uncontrolled outlet					Holding Pond	19.9 AF 2.6 acres Pump	$287,000
200	None					Holding Pond	12.4 AF 2.4 acres Pump and outlet pipe	$312,000
201	None					Holding Pond	10.8 AF 2.1 acres Pump	$229,000
202	None					Holding Pond	22 AF 4.3 acres Pump and outlet pipe	$449,000
203	None					Holding Pond	20.2 AF 3.8 acres Pump and outlet pipe	$403,000
204	None		1,300'			Holding Pond	16.3 AF 3.1 acres Pump and outlet pipe	$337,000
105	Pipe	24"	1,500'			Parallel Pipe	24"	$61,000
136	Pipe	12"	1,500'			Parallel Pipe	48"	$137,000
79	Pipe	30"	1,500'			Parallel Pipe	24"	$61,000
133	Pipe	30"	1,000'			Parallel Pipe	24"	$41,000
41	Channel	10'	600'	2:1	2.5'	Diversion Pipe	48"	$55,000
59	Box Culvert	2.5'	2,600'	0	1'	Diversion Pipe	24"	$106,000
139	Pipe	18"	1,000'			Parallel Pipe	36"	$65,000
205	None					Holding Pond	1 AF 1 acre Pump and outlet pipe	$91,000
206	None					Holding Pond	22 AF 4.3 acres Pump and outlet pipe	$448,000
99	Pipe	36"	200'			Parallel Pipe	24"	$8,000

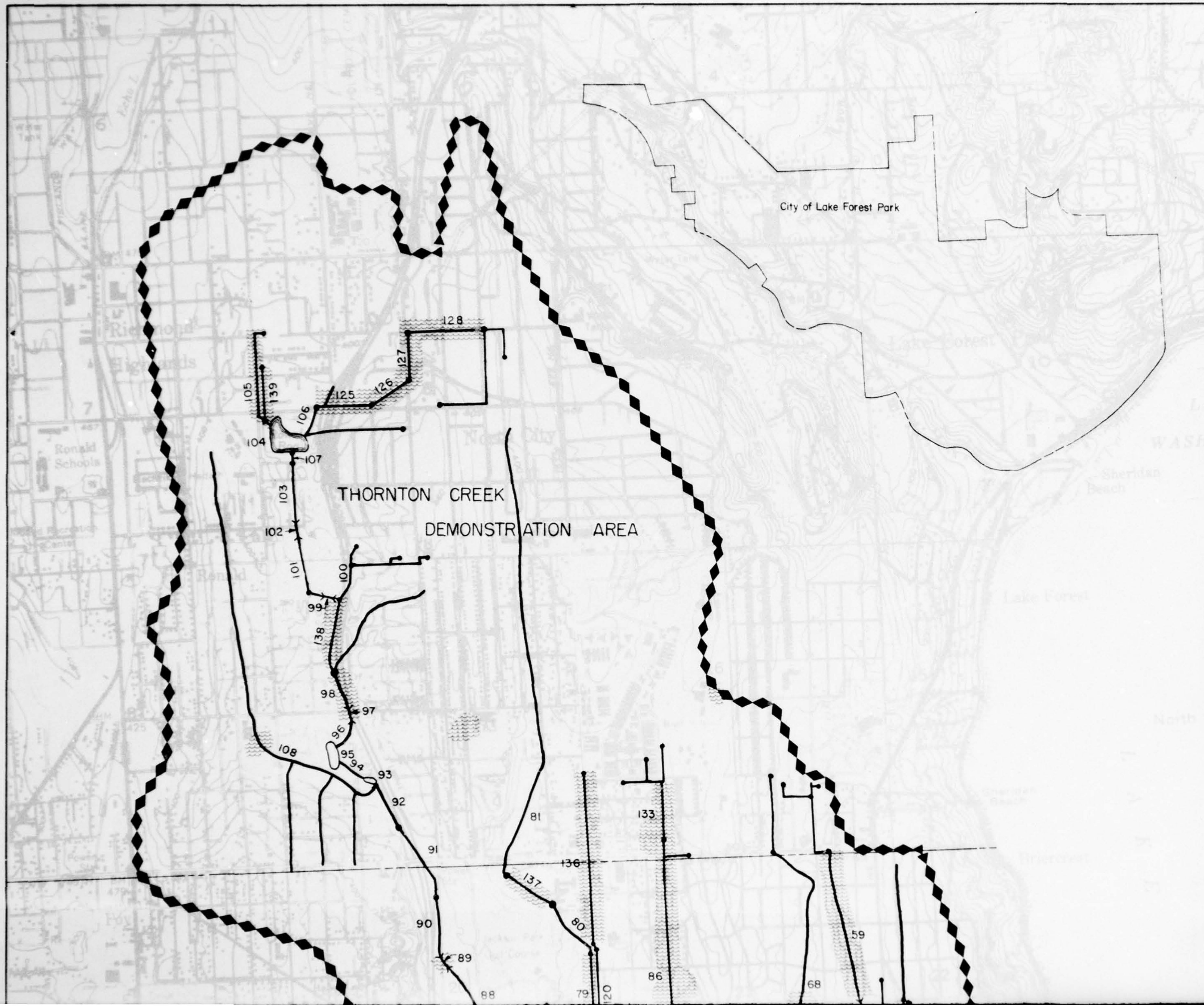
RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

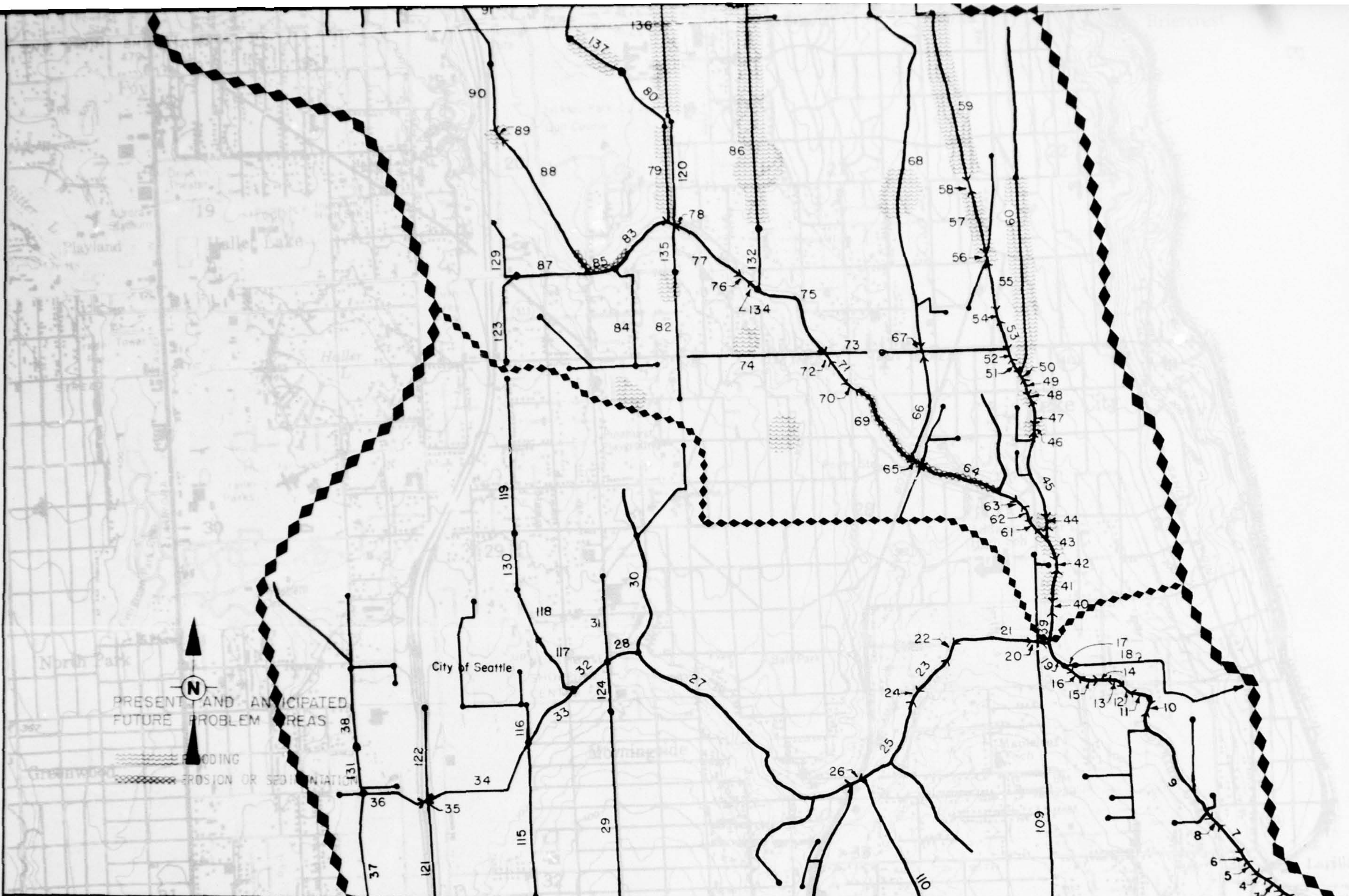
Alternative IV   Sub-Basin Thornton Creek Demonstration Area

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
138	Pipe	36"	1,300'			Parallel Pipe	24"	$53,000
98	Conc. Channel	3.5'	600'	0:0	1.3'	Diversion Pipe	24"	$25,000
97	Pipe	24"	60'			Parallel Pipe	48"	$6,000
83	Channel	15'	1,100'	2:1	1.5'	Diversion Pipe	36"	$72,000
57	Channel	3'	1,000'	1:1	1.5'	Diversion Pipe	24"	$41,000
56	Pipe	24"	100'			Parallel Pipe	24"	$4,000
60	Pipe	15"	3,200'			Parallel Pipe	24"	$131,000
50	Pipe	24"	40'			Parallel Pipe	36"	$3,000
44	Pipe	24"	40'			Parallel Pipe	36"	$3,000
48	Pipe	24"	40'	1:1	1.5'	Parallel Pipe	36"	$3,000
46	Pipe	24"	40'	1:1	1.5'	Parallel Pipe	36"	$3,000
43	Channel	5'	600'	1:1	2'	Diversion Pipe	48"	$55,000

The Estimated Capital Cost for each element includes Contractor profit, engineering, legal and contingencies. In addition, land purchase and [illegible] costs are included where land is required. All costs are based upon [illegible] prices.

Total Estimated Capital Cost: $3,537,000
Round To: $3,500,000


City of Lake Forest Park
THORNTON CREEK
DEMONSTRATION AREA
128
127
126
125
106
105
139
104
107
103
102
101
100
99
138
98
97
96
95
94
93
92
91
90
89
88
108
81
137
80
79
120
136
133
86
68
59
Ronald Schools
Richmond Highlands
North City
Lake Forest
Sheridan Beach
Briercrest



LEGEND

SUB-BASIN BOUNDARY
EXISTING CHANNEL
EXISTING CONDUIT
MANHOLE, INLET, OR JUNCTION
CHANNEL OR CONDUIT DESIG
CITY LIMITS
COUNTY (METRO) BOUNDARY
LEVEE

CULVERT
HOLDING POND OR LAKE

1/2 1/4 0 1
MILES

1000 500 0 4000
FEET

NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

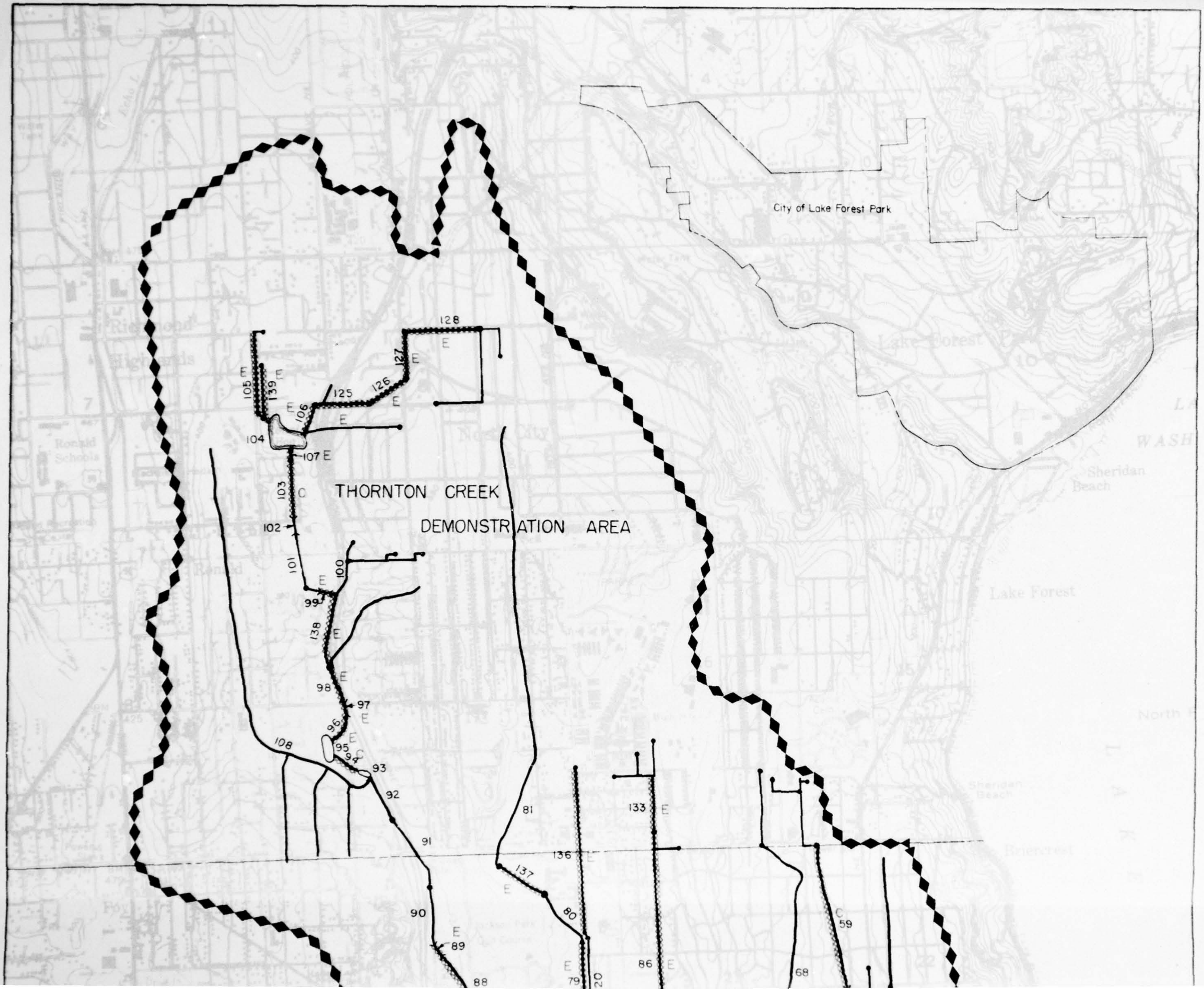
THORNTON CREEK DEMONSTRATION AREA

PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

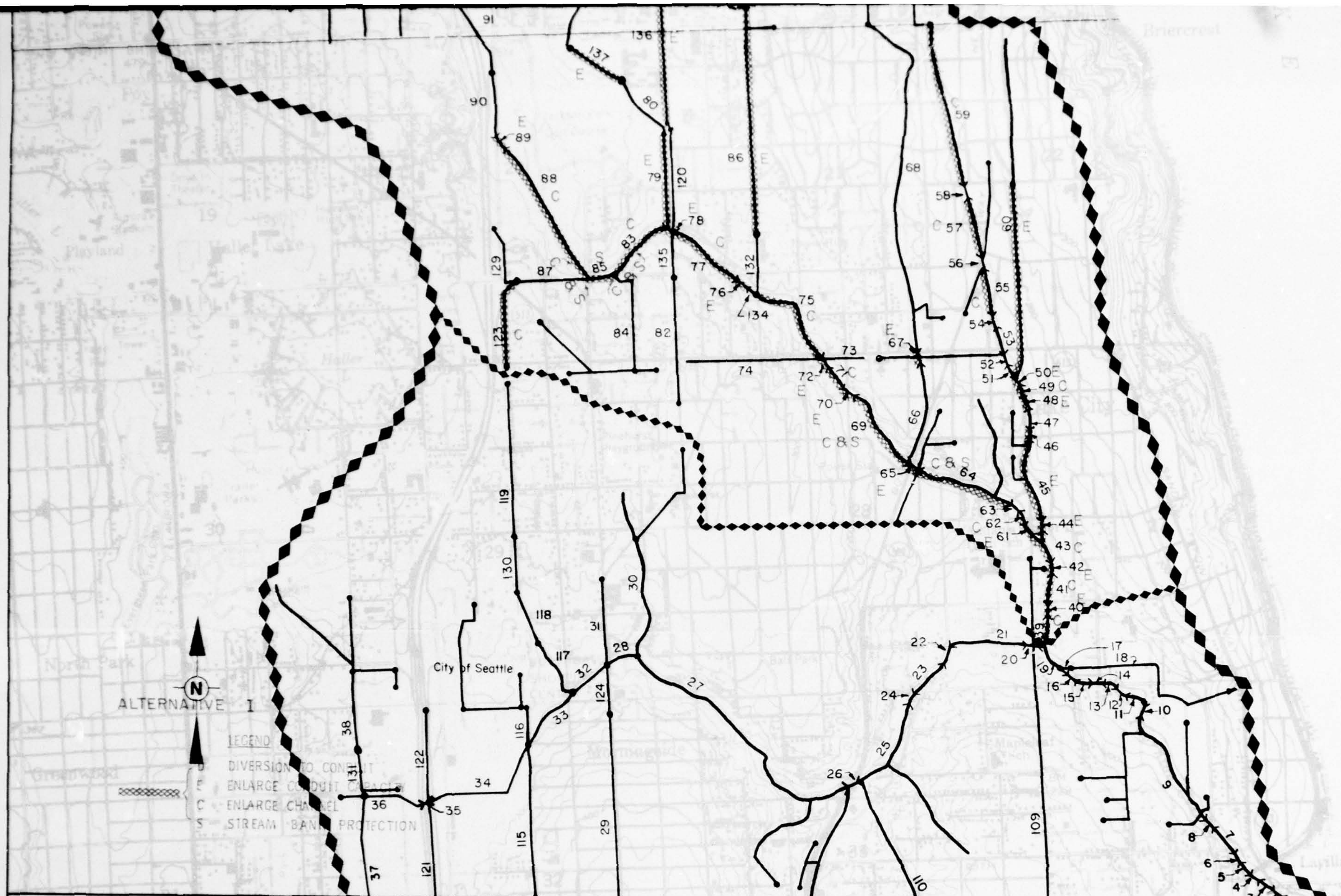
KRAMER, CHIN AND MAYO, INC
WATER RESOURCES ENGINEERS, INC
YODER, TROTTER, ORLOB & ASSOCIATES

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO E 26-1-161 SHEET 1a OF 1



THORNTON CREEK
DEMONSTRATION AREA
City of Lake Forest Park
Lake Forest Park
Lake Forest
Sheridan Beach
North City
Richmond Highlands
Ronald Schools
WASH
128
127
126
125
106
105
139
104
107
103
102
101
100
99
138
98
97
96
95
94
93
92
91
90
89
88
108
81
137
136
133
86
80
79
20
68
59
E
C



LEGEND

SUB-BASIN BOUNDARY
EXISTING CHANNEL
EXISTING CONDUIT
MANHOLE, INLET, OR JUNCTION
CHANNEL OR CONDUIT DESIG
CITY LIMITS
COUNTY (METRO) BOUNDARY
LEVEE

CULVERT
HOLDING POND OR LAKE

MILES: 1/2, 1/4, 0, 1

FEET: 1000, 500, 0, 4000

NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

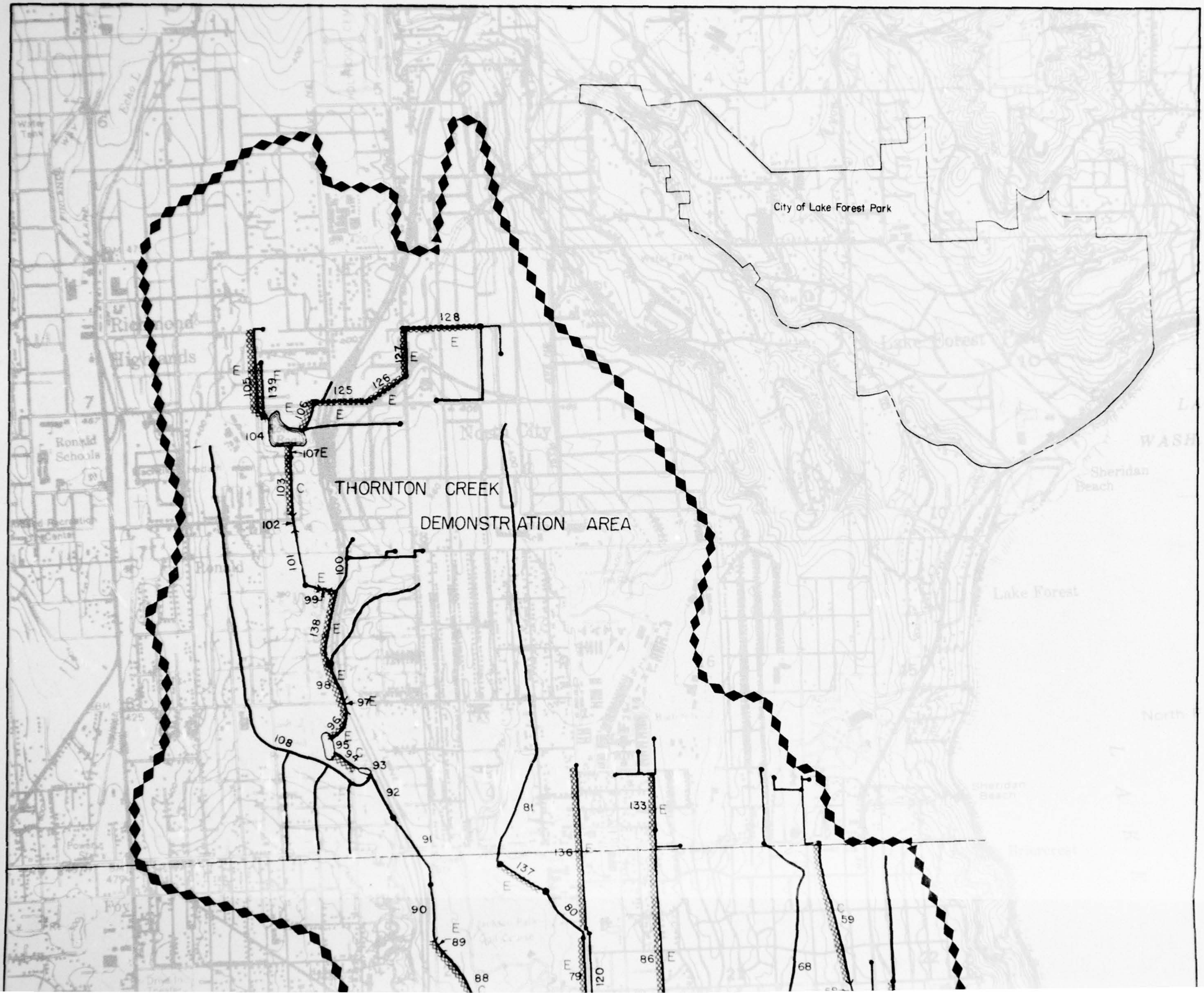
THORNTON CREEK DEMONSTRATION AREA

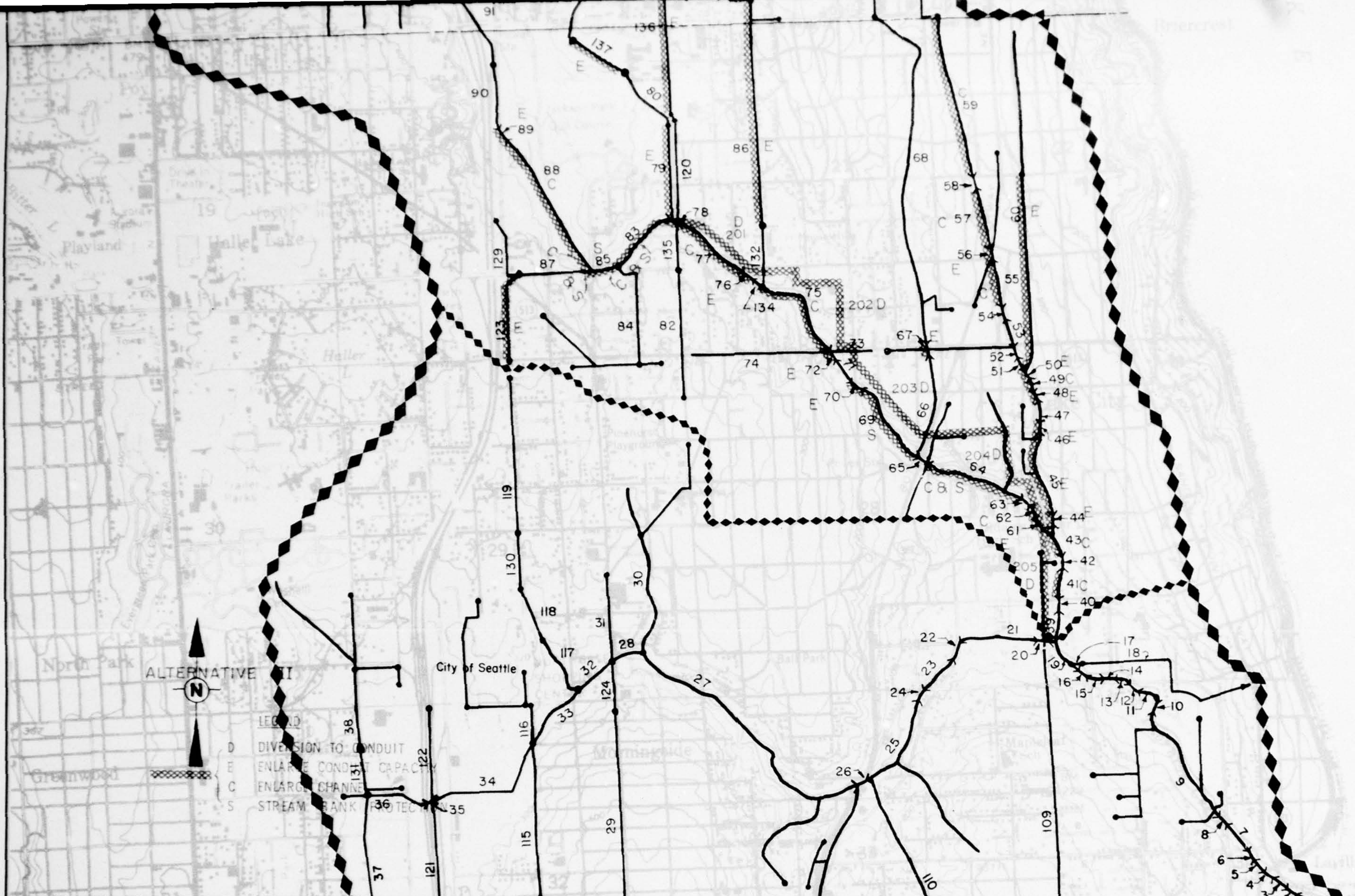
PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

KRAMER, CHIN AND MAYO, INC
WATER RESOURCES ENGINEERS, INC
YODER, TROTTER, ORLOB & ASSOCIATES

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO E 26.1.161 SHEET 1b OF 1


City of Lake Forest Park
THORNTON CREEK
DEMONSTRATION AREA
128
127
126
125
106
105
139
104
107E
103
102
101
100
99
138
98
97E
96
95
94
93
92
91
90
89
88
108
81
137
136
133
80
79
120
86
68
59
C
E



LEGEND

- SUB-BASIN BOUNDARY
- EXISTING CHANNEL
- EXISTING CONDUIT
- MANHOLE, INLET, OR JUNCTION
- CHANNEL OR CONDUIT DESIG.
- CITY LIMITS
- COUNTY (METRO) BOUNDARY
- LEVEE
- CULVERT
- HOLDING POND OR LAKE

1/2 1/4 0 1
MILES

1000 500 0 4000
FEET

NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

THORNTON CREEK DEMONSTRATION AREA

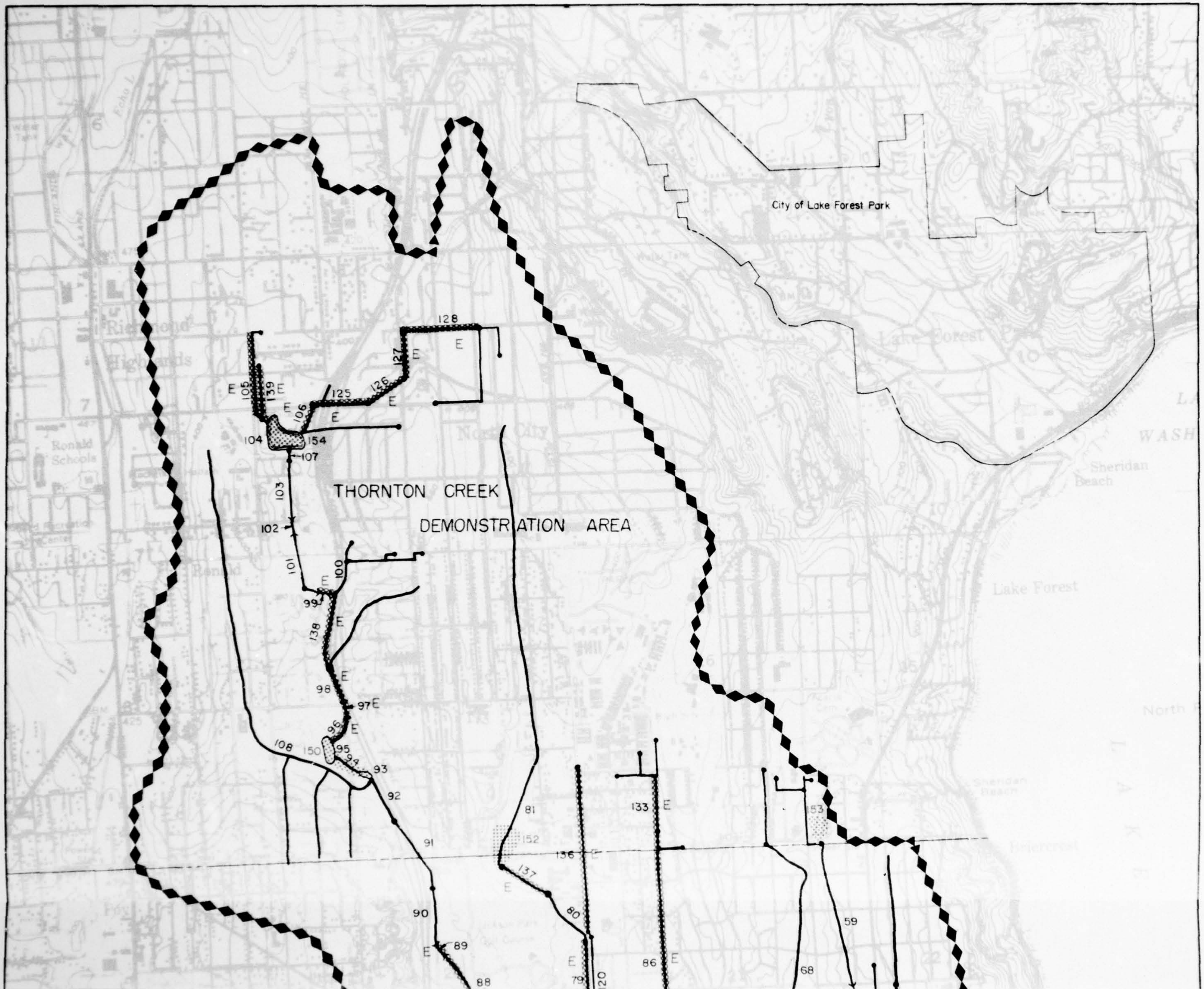
PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

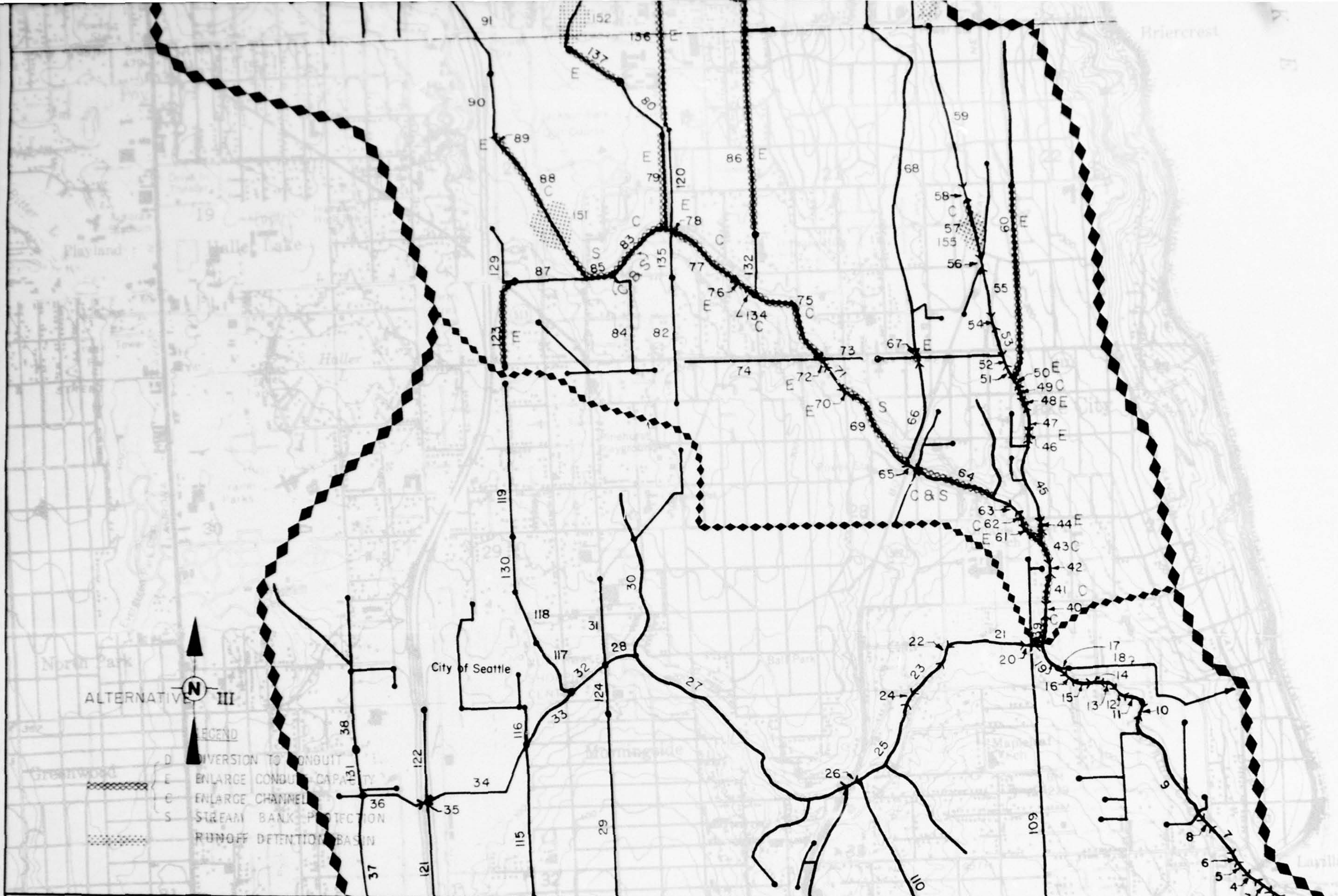
KRAMER, CHIN AND MAYO, INC
WATER RESOURCES ENGINEERS, INC
YODER, TROTTER, ORLOB & ASSOCIATES

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO E-26-1-161 SHEET 1c OF 1

2


City of Lake Forest Park
THORNTON CREEK
DEMONSTRATION AREA
Richmond Highlands
Ronald Schools
North City
Lake Forest
Sheridan Beach
WASH



LEGEND

SUB-BASIN BOUNDARY
EXISTING CHANNEL
EXISTING CONDUIT
MANHOLE, INLET, OR JUNCTION
CHANNEL OR CONDUIT DESIG S
CITY LIMITS
COUNTY (METRO) BOUNDARY
LEVEE

CULVERT
HOLDING POND OR LAKE

1/2 1/4 0 1
MILES

1000 500 0 4000
FEET

NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

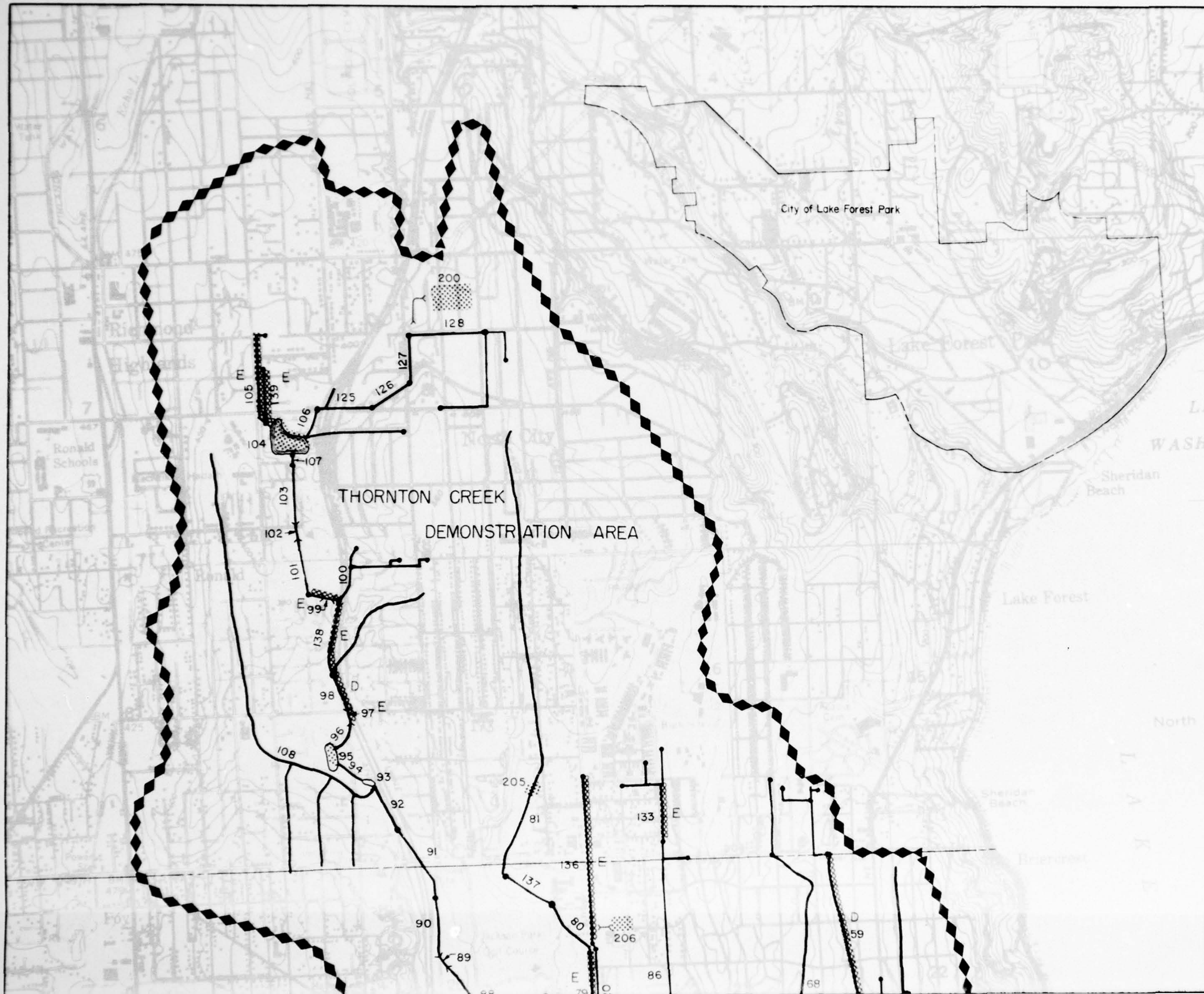
THORNTON CREEK DEMONSTRATION AREA

PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

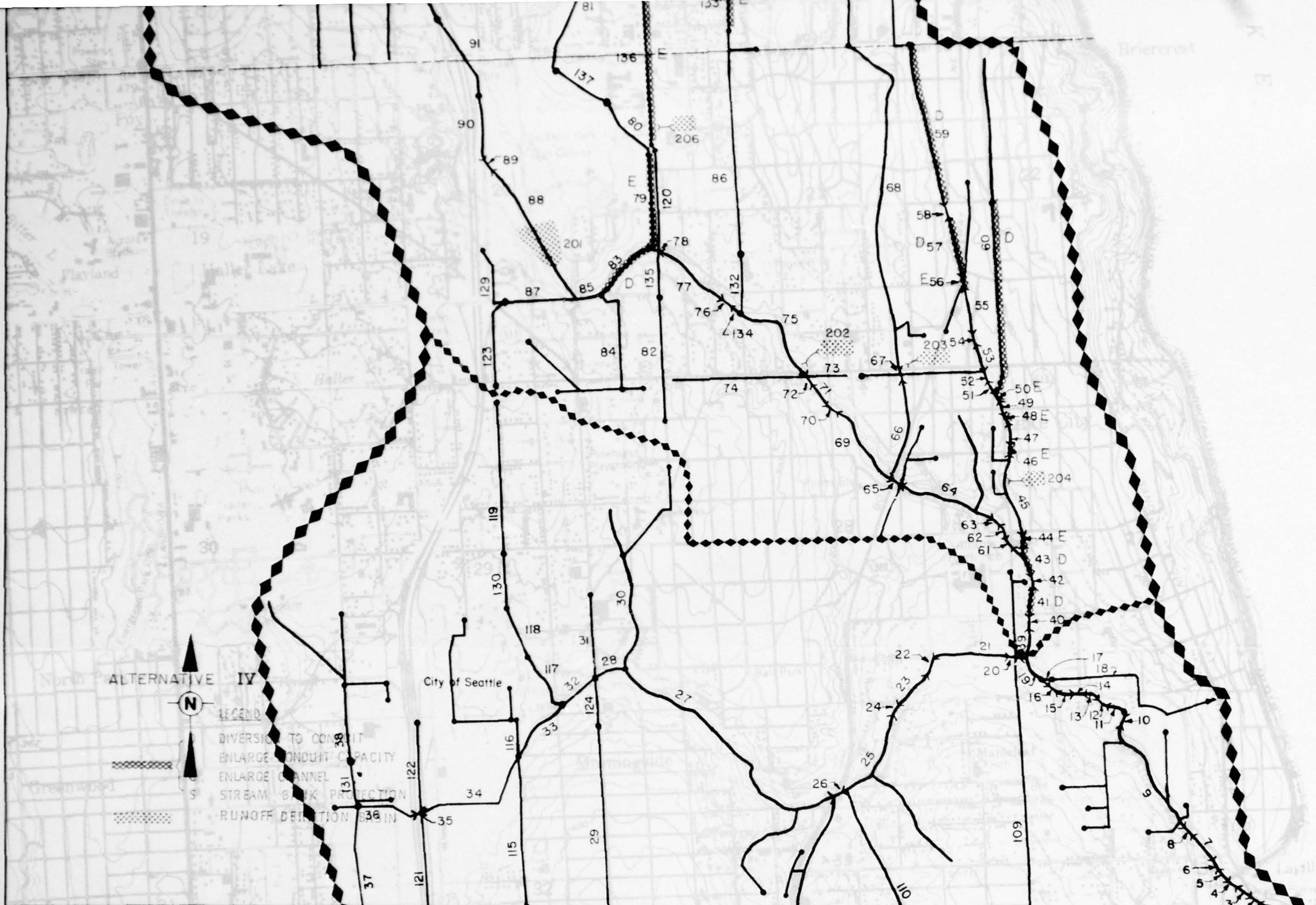
KRAMER, CHIN AND MAYO, INC.
WATER RESOURCES ENGINEERS, INC.
YODER, TROTTER, ORLOB & ASSOCIATES

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO E-26-1-161 SHEET 1 OF 1



City of Lake Forest Park
THORNTON CREEK
DEMONSTRATION AREA
200
128
127
126
125
106
105
139
E
E
104
107
103
102
101
100
99
E
138
E
D
98
97
E
96
95
94
93
92
91
90
89
108
205
81
137
136
E
80
206
E
86
133
E
68
D
59
Sheridan Beach
Lake Forest
North
Ronald Schools



LEGEND

SUB-BASIN BOUNDARY
EXISTING CHANNEL
EXISTING CONDUIT
MANHOLE, INLET, OR JUNCTION
CHANNEL OR CONDUIT DESIG
CITY LIMITS
COUNTY (METRO) BOUNDARY
LEVEE

CULVERT
HOLDING POND OR LAKE

1/2 1/4 0 1
MILES

1000 500 0 4000
FEET

NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

THORNTON CREEK DEMONSTRATION AREA

PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

KRAMER, CHIN AND MAYO, INC
WATER RESOURCES ENGINEERS, INC
YODER, TROTTER, ORLOB & ASSOCIATES

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO E-26.1.161 SHEET 1 OF 1

2

REGIONAL SUB-BASIN C-14

KELSEY CREEK DEMONSTRATION AREA

GENERAL DESCRIPTION

The Kelsey Creek sub-area is a portion of the Mercer Slough Sub-Basin. Kelsey Creek is located between Lake Washington and Lake Sammamish within the northeast quadrant formed by the intersection of Interstate 90 and Interstate 405. The sub-area lies generally in a north-south direction with two tributaries draining areas of north and central Bellevue, and Redmond. The City of Bellevue has jurisdiction over most of this sub-area, with the northern fringe area being controlled by Redmond.

Geography of the sub-area is typical of the central Puget Sound region with moderately rolling hills, gullies, and wetlands. Elevations range from over 500 ft. to approximately 20 ft. above sea level before entering Mercer Slough. Principal streams of the system are Kelsey Creek and Valley Creek.

Streams	Category	Drainage Area	Discharge
Kelsey Creek	III	9.4 sq. mi.	Mercer Slough
Valley Creek	III	2.6 sq. mi.	Kelsey Creek

Present development is a mixture of residential, commercial, industrial, institutional and transportation uses, plus some agricultural, public open space and vacant land. This sub-area has passed the 50% development mark.

PERCENT OF SUB-AREA IN SPECIFIED LAND USE

Land Use	Existing (1970-72)	P.S.G.C. Land Use Projection	
		Comprehensive	Corridor
Single Family	45	45	47
Multiple Family	5	10	5
Commercial/Services	15	20	15
Govt. and Educ.	3	5	3
Industrial	10	17	15
Parks/Dedicated Open Space	5	2	14

Land Use	Existing (1970-72)	P.S.G.C. Land Use Projection Comprehensive	Corridor
Agriculture	2		
Airports, Railyards, Freeways, Highways	1	1	1
Unused Land	14		
Water	1	1	1
Total	100	100	100
Total Impervious Area	40	55	50

Patterns of land use in this sub-area are defined and future development should tend to fill in the voids. Massive development projects, such as the proposed Evergreen East, without adequate runoff controls, will greatly impact the drainage system.

The PSGC year 2000 Comprehensive and Corridor Plans both project 100% development within the sub-area, with significant increases of commercial and industrial land use.

Public concern over the future of Kelsey Creek is intense. The City of Bellevue, with jurisdictional control over most of the watershed, recently designated Kelsey Creek as part of a drainage utility system that will make use of the various streams and wetlands in Bellevue in their natural state. Interest in the Kelsey Creek system as a natural element to be preserved is expressed by the continuing involvement of the Bellevue Citizens Advisory Committee on Stream Resources, a group created by the Bellevue City Council.

NATURE OF EXISTING DRAINAGE SYSTEM

The existing drainage system is a combination of the natural streams, one lake, wetland areas and extensive structural facilities, including curbs, gutters, culverts and pipes.

Kelsey Creek has a diminishing potential as an urban greenway because development encroaches upon the streambanks. The stream has been incorporated into development of numerous residential properties and access along the stream is inhibited by barriers such as bridges, culverts and fences. There is an existing population of cutthroat trout and coho salmon that require high-quality water for survival. However, other stream life evident in the system is of the pollution-tolerant variety that indicates a degradation of stream ecology. The sub-area is served by Metro for sanitary sewerage.

DRAINAGE PROBLEMS

The Kelsey Creek sub-area has experienced problems of flooding and erosion. Flooding problems are mainly located on the tributaries to the main channel. Control of unwise development practices has eliminated the major cause of erosion and sedimentation within Kelsey Creek. Streambank erosion has been experienced along Kelsey Creek in the Glendale golf course, and bank protection has been placed at several locations by the property owner.

Major flooding occurs in the Larson Lake area and adjacent to 148th Street between Main Street and the 148th Street culvert north of N.E. 8th Street. Flooding occurs both as surcharging of existing storm drains and as overbank flooding of the creek channel.

Both the year 2000 Comprehensive and Corridor Land-Use Plans indicate further urbanization of the Kelsey Creek sub-area. No significant hydrologic difference exists between the Comprehensive and Corridor Land Use Plans. Therefore, the drainage alternatives presented herein are applicable to both plans. The existing drainage problems will become more severe because of increases in impervious areas and faster runoff. The total impervious area in this sub-area, with either land use projection, will increase from an existing 40% level to approximately 50% as shown in the table of projected land uses.

Analyses indicate flooding potential in the area of 148th Street and the Bellevue-Redmond Road, and ponding is predicted at N.E. 24th on Valley Creek. Flooding at most road culverts along the west tributary of Kelsey Creek is predicted. The ponding behind these road culverts prevents major overbank flooding problems in the lower reaches. The lower portion of Kelsey Creek and its west tributary, which runs into the marsh area above I-405, has a wide flood plain because of the flat terrain and dense vegetation. Projections of future drainage problems indicate an intensification of existing problems, plus a few additional problems in both the Larson Lake area and above N.E. 20th.

Reported property damages obtained from local agencies placed the average annual loss for Kelsey Creek sub-area at $9,640.

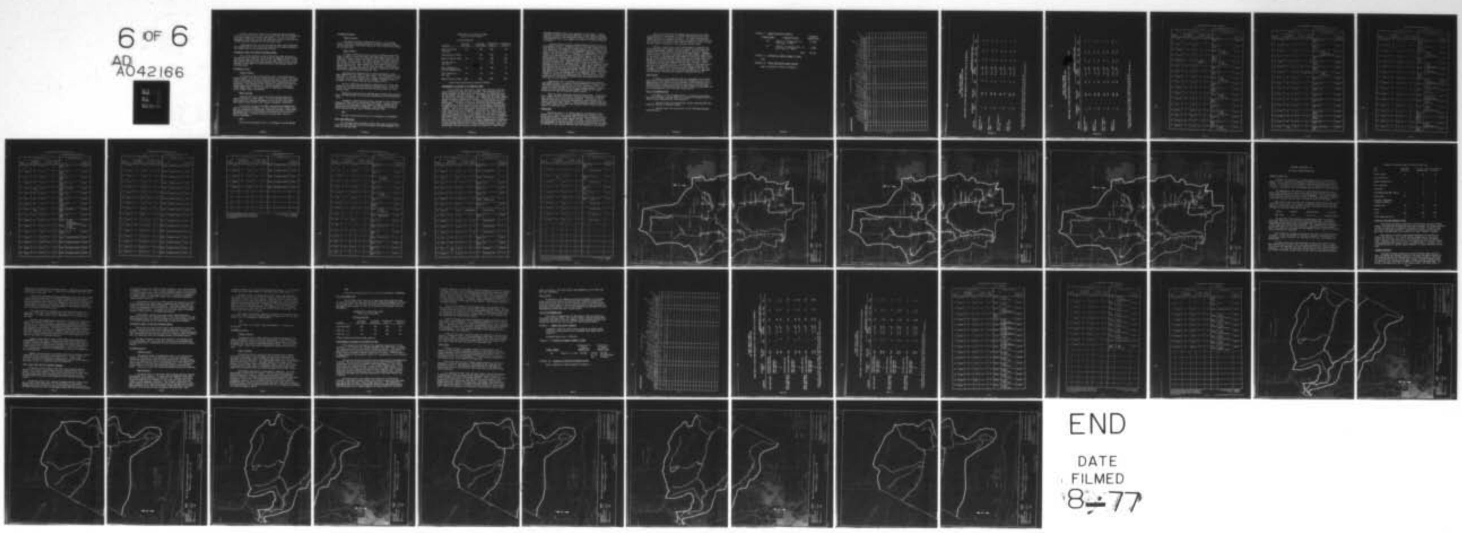
BASIC ISSUES AND STATUS OF DRAINAGE PLANNING

As cited above, the City of Bellevue has designated Kelsey Creek in its natural state as part of the City's drainage utility. The utility would assess all sub-area property owners a monthly service charge for introducing runoff from impervious surfaces into the system. The City also is considering alternative land-use plans based upon watershed drainage characteristics. The execution of these actions is critical as the Kelsey Creek system is in a deteriorating state. Bellevue also has a unique "clearing and grading" ordinance that requires control of runoff from properties being developed.

AD-A042 166 KCM-WRE/YTO SEATTLE WASH F/G 8/8
ENVIRONMENTAL PLANNING FOR THE METROPOLITAN AREA CEDAR-GREEN RI--ETC(U)
DEC 74 DACW67-73-C-0022

UNCLASSIFIED NL

6 OF 6
AD A042166



END
DATE
FILMED
8-77

Bellevue advocates retention of wetlands and the development of areas that provide open space during dry periods and act as detention ponds and storage areas during storm periods. The use of watershed management, flood-plain zoning, and storm water diversion also are considered important components of the drainage system.

Staff members from the City of Bellevue Public Works Department have reviewed the initial alternative plans for drainage developed by this RIBCO study for the Kelsey Creek sub-area.

ALTERNATIVE PLANS FOR PROPOSED DRAINAGE CONTROL

The existing drainage system of the Kelsey Creek sub-area as described by local agencies, was evaluated by computer simulation that applied the region's 10-year storm to the year 2000 land use. Drainage problems thus identified were analyzed and possible solutions were provided in development of alternative plans for drainage control as described below.

ALTERNATIVE PLAN I

General Concept

The general concept of Alternative Plan I is continuation of present trends. This involves channelization of the creek, increasing culvert and bridge sizes and increasing storm drain sizes to pass peak flows as indicated by the future land-use plan, unrestricted and uncontrolled. This alternative will relieve all present and future predicted system constraints and will thereby generate significantly higher runoff rates. This alternative is presented as a reference point to judge future alternatives.

Major Features

The major portion of the Kelsey Creek drainage system will require alteration in some manner. In the Larson Lake area, most storm drains will require enlargement as will culverts and channels. Some steeply-sloped channels will require streambank protection.

The drainage system in the 148th Street/Bellevue-Redmond Road area will require enlargement. On Valley Creek various culverts will need to be enlarged and streambank protection provided. Some channel improvements will be required below the confluence of Valley Creek and Kelsey Creek. The west tributary of Kelsey Creek also will require improvement.

Cost

The cost for Alternative Plan I is estimated to be $4,000,000.

ALTERNATIVE PLAN II

General Concept

The general concept of Alternative Plan II is to provide relief of existing drainage problems by providing adequate storage and by requiring on-site runoff control to limit future flows throughout the watershed.

Major Features

Six major holding ponds will be used to attenuate downstream flows in order to lessen the impact upon downstream facilities. The ponds are located in areas that usually retain water under existing conditions. Modifications will need to be made to provide control of the storage in these areas. The pond locations on Kelsey Creek are the Larson Lake area, 148th between N.E. 8th and Main Street, and between 148th and N.E. 8th. Valley Creek will have a pond above N.E. 24th Street. The pond locations on the west tributary will be above the Bellevue-Redmond Road and above N.E. 8th.

One additional detention area is required adjacent to the Sears-Roebuck facility north of 20th Street. The site presently holds water and is a natural wetlands area. Special construction is not envisioned, but the area should not be allowed to develop without replacement of the storage capacity that presently exists.

On-site runoff control should be required for all future development so as to maintain runoff rates at present levels. This will relieve the increased problems that were predicted under the future land-use plans.

Flood-plain zoning will be provided where streams would overflow their low-flow channels but would not encroach upon existing developed areas.

Streambank protection has not been included in this alternative because the flows will be sufficiently controlled. Previous erosion problems are not expected to occur again as property owners have repaired and protected their streambanks after the March 1972 storm, which produced the peak flow of record on Kelsey Creek.

Cost

The cost for Alternative Plan II is estimated to be $900,000.

PEAK FLOW COMPARISONS

The following table indicates 10-year peak flows with existing facilities and land use, and with alternative drainage management solutions for the year 2000.

COMPARISON OF 10-YEAR PEAK FLOWS
(Cubic Feet Per Second)

Existing Land Use

Location	Existing Facilities	Existing Facilities*	Alternative Plan I	Alternative Plan II
Outlet of Larson Lake area	105	105	335	50
Kelsey Creek at 148th	-	165	625	50
Mouth of Valley Creek	50	175	700	200
Kelsey Creek at N.E. 8th	-	-	1220	240
West tributary at Bellevue-Redmond Road	30	30	260	30
West tributary at N.E. 8th	95	95	475	90
Mouth of Kelsey Creek	400	415	1750	425

* Note flows constricted by upstream flooding

ENVIRONMENTAL ASSESSMENT OF ALTERNATIVE PLANS

Field inspections were made to judge applicability of the suggested alternative plans for this sub-area. This procedure was followed throughout the RIBCO Study for development of alternative plans for the various regional sub-basins. The inspections were based upon the alternative evaluation procedure which identified 34 unique criteria grouped in general categories as follows: 1) Effectiveness, 2) Human Values, 3) Environmental Factors, 4) Implementation, and 5) Resource Requirements. The various structural solutions were checked against the appropriate criteria and the various non-structural solutions were reviewed for their relationship to existing and probable future developments. The criteria rating total for Alternative Plan I, which employs channelization and streambank protection, was a minus 32 on a scale ranging from positive 108 to negative 108. The total evaluation rating for Alternative Plan II, which employs runoff control, storage, some channelization and flood-plain zoning, was a plus 67. Alternative Plan II is judged to be superior for effectiveness of runoff control based upon its overall reliability and minor consequences of overcharge. It also provides positive erosion and sedimentation control as well as allowing maximum flexibility for future system alteration. Both alternative plans received positive ratings for promotion of human values,

although Alternative Plan II was superior in this regard. Alternative Plan II offers multiple-use potential and will provide greenway potential because of the flood-plain zoning. The aesthetic qualities of Alternative Plan II are judged to be superior to those of Alternative Plan I.

The two alternative plans received widely divergent scores for environmental factors. Alternative Plan II received a nearly perfect score because of the promotion of water quality, the assurance of low-flow conditions, the potential for groundwater recharge, minimal alteration of the natural system and the positive enhancement of wildlife, aquatic life and vegetation. In contrast, Alternative Plan I is believed to be potentially harmful to wildlife, aquatic life and vegetation because it requires major alteration of the natural system. Alternative Plan I would have questionable impact upon water quality and low-flow conditions. Both alternative plans are judged to be relatively difficult to implement, even in light of the recently created drainage utility in the City of Bellevue. Some runoff enters the system from outside the City of Bellevue, therefore additional legislation would be required and both systems require relatively extensive land acquisition. Alternative Plan II, in addition, would be severely impacted if it was not implemented in the immediate future. This is a result of the continuing deterioration of the Kelsey Creek natural system and the continuing encroachment upon the wetlands which are a vital part of this solution.

Alternative Plan II received a positive rating for resource requirements because it requires little expenditure of energy or materials while allowing a multiple-use of land. Alternative Plan I received the lowest possible score in this category because it requires extensive energy and material requirements in addition to single-purpose use of land and extensive capital outlay.

There are known trade-offs with both alternatives. Alternative Plan I would sacrifice the natural system for the ability to develop more intensive land uses within this sub-area. Alternative Plan II requires flood-plain zoning and designation of major wetland areas to achieve effective runoff control. The designation of these flood-plain areas would effectively remove them from any future intensive land uses typical of urbanized areas.

CONCLUSIONS

Alternative Plan II is clearly superior to Alternative Plan I because of its ability to utilize remaining natural features of the Kelsey Creek system. Alternative Plan II does require immediate action to protect and preserve these natural features. As pointed out above, this would require control of runoff at or near existing rates for any new development and the designation of necessary flood plains and access or easement to the numerous wetlands that are elements of this system.

The cities of Bellevue and Redmond should establish an effective agreement for development of a master drainage plan that incorporates provision of Alternative Plan II. The above cited agencies should then move to implement and enforce the required runoff controls and flood-plain zoning within their own jurisdiction, as well as securing the rights or easements to the necessary wetland areas.

Two basic issues exist. One is which agency or agencies will have jurisdiction and responsibility for control of urban runoff and related flood damage problems, and the second is the use of natural system versus a conversion to a primarily man-made system. Regarding the first issue, the City of Bellevue should have primary responsibility for control of drainage and flood damage for the Kelsey Creek system, but the City of Redmond should control flood-plain zoning, within its boundaries as well as exercise enforcement power for runoff control. The second issue has been addressed by the City of Bellevue in the creation of its drainage utility. The development of the master drainage plan will determine what portion of the natural system will be utilized. Agreement will still be necessary, however, with the City of Redmond to assure that runoff from that jurisdiction is compatible with the design limitations as proposed in Alternative Plan II.

EARLY ACTION

In addition to the immediate need for development of a drainage master plan and designation of jurisdictional leadership within this demonstration area, certain physical features of the alternative plans, presented herein, appear to be generally applicable to any drainage plan which may be forthcoming as well as both suitable and desirable for early implementation within the next 10-year period.

FACILITY RECOMMENDATIONS

The emphasis of the recommendations is to preserve and enhance the existing natural drainage system as indicated in Alternative Plan II. Specific early implementation items should be:

1. Acquire options to purchase those larger-sized wetlands that presently function as detention basins.

2. Proceed toward the construction of the following drainage system elements:

Category I - Common Alternative Elements

Element Number	Proposed Facility	Estimated Capital Cost
158	channel, 3' bottom width, 2:1 side slope, 3' depth	$ 9,000
174	channel, 2.5' bottom width, 2:1 side slope, 2.5' depth	1,000
	TOTAL	$10,000

Category II - Alternative Elements Common in Scope

None

Category III - Minor Reported Drainage Problems

None in addition to those in Category I.

EVALUATION MATRIX

KELSEY CREEK DEMONSTRATION AREA

ALTER-NATIVES	SUB TOTAL	EFFECTIVENESS								SUB TOTAL	HUMAN VALUES							SUB TOTAL	ENVIRONMENTAL FACTORS									SUB TOTAL	IMPLEMENTATION						SUB TOTAL	RESOURCE REQUIREMENTS				RATING TOTAL
		Use of existing facilities	System reliability	System maintainability	System flexibility	Flood damage reduction	Consequences of overcharge	Erosion and sedimentation control	Cost/benefits ranking		Urban quality (aesthetics)	Effect on land use	Displacement of people	Educational value	Community cohesion	Multiple use potential	Public health and safety		High flow conditions	Alteration of natural system	Effects on groundwater	Low flow conditions	Water quality	Construction disruption	Effects on wildlife	Effects on aquatic life	Effects on vegetation		Legislative requirements	Jurisdictional	Land acquisition	Public acceptance	Financing	Effects of no action		Energy	Materials	Land	Capital	
		CRITERIA WEIGHT									CRITERIA WEIGHT								CRITERIA WEIGHT										CRITERIA WEIGHT							CRITERIAWEIGHT				
		1	4	3	2	4	4	4	2		4	2	2	1	3	3	4		4	4	4	4	4	2	4	4	4		4	4	2	4	4	3		3	3	2	2	
I	- 5	-1 -1	0	0	-1 -2	+1 +4	-1 -4	0	-1 -2	+4	0	+1 +2	+1 +2	0	0	0	0	-18	0	-1 -4	0	0	0	-1 -2	-1 -4	-1 -4	-1 -4	-3	0	0	-1 -2	-1 -4	0	+1 +3	-10	-1 -3	-1 -3	-1 -2	-1 -2	-32
II	+25	+1 +1	+1 +4	0	+1 +2	+1 +4	+1 +4	+1 +4	+1 +2	+9	+1 +4	-1 -2	0	+1 +1	+1 +3	+1 +3	0	+32	+1 +4	+1 +4	+1 +4	+1 +4	+1 +4	0	+1 +4	+1 +4	+1 +4	-1	0	0	-1 -2	+1 +4	0	-1 -3	+ 2	0	0	+1 +2	0	+67

RUNOFF QUALITY SUMMARY
KELSEY CREEK DEMONSTRATION AREA

BASED UPON A 10-YEAR STORM PRECEDED BY 5 DAYS WITH LITTLE OR NO RAINFALL#

LOCATION	ALTERNATIVE PLAN	PEAK FLOW (cfs)	CONCENTRATION AT PEAK FLOW*				
			BOD	TOTAL COLIFORM	NH_3	$NO_2 + NO_3$	PO_4
Kelsey Creek at 148th St.	I	625	6	2.1×10^5	.3	.5	.1
	II	50	9	2.4×10^5	.4	.7	.2
Mouth of Valley Creek	I	700	6	2.0×10^5	.2	.4	.1
	II	200	11	4.3×10^5	.5	.9	.2
West Tributary at N.E. 8th	I	475	7	1.7×10^5	.3	.5	.1
	II	90	7	1.4×10^5	.2	.5	.2
Mouth of Kelsey Creek	I	1750	11	3.3×10^5	.4	.8	.2
	II	425	11	3.6×10^5	.5	.9	.2

Less than a total of 0.5 inches of rainfall in any one day.
* Concentrations in mg/liter except total coliform which is in MPN/100 ml.

RUNOFF QUALITY SUMMARY
KELSEY CREEK DEMONSTRATION AREA

BASED UPON A 10-YEAR STORM PRECEDED BY 15 DAYS WITH LITTLE OR NO RAINFALL#

LOCATION	ALTERNATIVE PLAN	PEAK FLOW (cfs)	CONCENTRATION AT PEAK FLOW*				
			BOD	TOTAL COLIFORM	NH_3	$NO_2 + NO_3$	PO_4
Kelsey Creek at 148th St.	I	625	18	6.3×10^5	.8	1.4	.4
	II	50	27	$.7 \times 10^6$	1.0	2.0	.5
Mouth of Valley Creek	I	700	17	$.6 \times 10^6$	.7	1.3	.3
	II	200	34	1.3×10^6	1.5	2.7	.7
West Tributary at N.E. 8th	I	475	21	$.5 \times 10^6$	.8	1.5	.4
	II	90	23	4.4×10^5	.7	1.6	.5
Mouth of Kelsey Creek	I	1750	70	2.13×10^6	2.8	5.2	1.4
	II	425	34	1.0×10^6	1.4	2.6	.7

Less than a total of 0.5 inches of rainfall in any one day.
* Concentrations in mg/liter except total coliform which is in MPN/100 ml.

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative I   Sub Basin Kelsey Creek Demonstration Area

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
177	Pipe	18"	1,140'			Parallel Pipe	27"	$54,000
176	Pipe	18"	1,250'			Parallel Pipe	36"	$82,000
174	Channel	2'	500'	1:1	2.5'	Channel	2.5' width 2.5' depth 2:1 side slopes	$1,000
171	Culvert	30"	60'			Replacement Culvert	36"	$9,000
163	Channel		700'	No defined channel		Channel	4' width 6' depth 2:1 side slopes	$17,000
161	Pipe	24"	950'			Parallel Pipe	21"	$34,000
159	Pipe	36"	900'			Parallel Pipe	27"	$43,000
158	Channel	3'	3,100'	1:1	3'	Channel	3' width 3' depth 2:1 side slopes	$9,000
157	Pipe	12"	650'			Replacement Pipe	18"	$20,000
154	Culvert	24"	50'			Replacement Culvert	8' x 2'	$15,000
153	Channel	3'	550'	1:1	3'	Channel	12' width 3' depth 2:1 side slopes	$5,000
151	Culvert	84"	100'			Replacement Culvert	6' x 5'	$32,000
149	Pipe	18"	280'			Parallel Pipe	24"	$12,000
148	Channel	10'	1,550'	2:1	3'	Channel	20' width 3' depth 2:1 side slopes	$12,000
143	Pipe	18"	1,000'			Parallel Pipe	12"	$20,000
142	Culvert	36"	40'			Replacement Culvert	12' x 3'	$7,000
141	Channel	6'	700'	2:1	3'	Channel	15' width 3' depth 2:1 side slopes	$5,000

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative I   Sub-Basin Kelsey Creek Demonstration Area

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
140	Culvert	36"	100'			Replacement Culvert	13' x 3'	$48,000
137	Culvert	42"	24'			Replacement Culvert	8' x 6'	$5,000
136	Channel	6'	900'	.5:1	7'	Channel	6' width 7' depth 2:1 side slopes Streambank protection	$108,000
134	Pipe	18"	160'			Replacement Pipe	36"	$10,000
133	Culvert	5.25'	120'	0	3.8'	Replacement Culvert	8' x 7'	$50,000
104	Culvert	12'	175'	Arch	6'	Replacement Culvert	9' x 6'	$73,000
105	Channel		1,200'	No defined channel		Channel	9' width 6' depth 1:1 side slopes	$27,000
111	Pipe	21"	1,550'			Parallel Pipe	18"	$47,000
112	Pipe	48"	450'			Parallel Pipe	48"	$41,000
113	Pipe	30"	650'			Parallel Pipe	24"	$27,000
114	Pipe	24"	360'			Parallel Pipe	21"	$13,000
115	Pipe	21"	260'			Parallel Pipe	24"	$11,000
116	Pipe	48"	700'			Parallel Pipe	60"	$83,000
118	Culvert	36"	72'			Replacement Culvert	48"	$14,000
120	Culvert	24"	60'			Replacement Culvert	54"	$14,000
122	Pipe	24"	100'			Parallel Pipe	36"	$7,000
124	Pipe	72" rough	200'			Replacement Pipe	66" smooth	$36,000

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative I Sub-Basin Kelsey Creek Demonstration Area

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
126	Culvert	36"	40'			Replacement Culvert	7' x 3'	$12,000
128	Culvert	48" rough	60'			Replacement Culvert	48" smooth	$13,000
129	Channel	2'	6,400'	1:1	1.5'	Channel	4' width 2' depth 2:1 side slopes Streambank protection	$227,000
102	Pipe	18"	400'			Replacement Pipe	42"	$31,000
100	Channel	26'	1,000'	1:1	3'	Channel	20' width 5' depth 2:1 side slopes Streambank protection	$89,000
98	Channel	9'	1,000'	1:1	5'	Channel	20' width 6' depth 2:1 side slopes Streambank protection	$126,000
97	Culvert	10'	100'		6'	Replacement Culvert	15' x 6'	$64,000
95	Channel	40'	3,900'	1:1	3.5'	Channel	60' width 4' depth 1:1 side slopes Streambank protection	$201,000 Land cost not included
64	Channel	10'	400'	1:1	2'	Channel	110' width 2' depth (Land cost not includ.) Vertical side slopes	$17,000
65	Bridge	15'	20'	0	4.5'	Bridge	60' width 2' depth Vertical sides	$18,000
216	Channel	15'	1,000'	1:1	2'	Channel	50' width/2' depth 1:1 side slopes Streambank protection (Land cost not includ.)	$30,000
217	Bridge	15'	30'	0	2.5'	Bridge	20' width 2.5' depth Vertical sides	$10,000
218	Channel	8'	1,650'	0	2'	Channel	35' width 2' depth 1:1 side slopes (Land cost not includ.)	$21,000
219	Culvert	4'	60'			Replacement Culvert	60"	$17,000
220	Culvert	3.5'	60'			Replacement Culvert	8' x 4'	$21,000
221	Channel	7'	1,450'	0	2'	Channel	12' width 4' depth 1:1 side slopes Streambank protection	$49,000
67	Culvert	5'	80'	0	4.5'	Replacement Culvert	8' x 5'	$29,000

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative I Sub-Basin Kelsey Creek Demonstration Area

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
70	Pipe	36"	1,150'			Parallel Pipe	72"	$170,000
72	Culvert	48"	60'			Replacement Culvert	66"	$18,000
74	Pipe	36"	700'			Replacement Pipe	42"	$61,000
77	Culvert	21"	40'			Replacement Culvert	5' x 2.5'	$9,000
79	Pipe	39" rough	100'			Replacement Pipe	36" smooth	$12,000
82	Pipe	48"	370'			Replacement Pipe	60"	$53,000
84	Pipe	42"	350'			Replacement Pipe	48"	$39,000
86	Culvert	48"	60'			Replacement Culvert	60"	$16,000
88	Pipe	36" rough	120'			Replacement Pipe	36" smooth	$13,000
90	Pipe	24"	75'			Replacement Pipe	36"	$10,000
63	Channel	30'	1,000'	4:1	3'	Channel	500' width 3' depth 4:1 side slopes (No land cost includ.)	$314,000
138	Channel	10'	300'	2:1	6'	Channel	25' width 6' depth 2:1 side slopes	$7,000
206	Culvert	36'	100'	0	5.5'	Parallel Culvert	13' x 6'	$51,000
73	Channel	8'	2,000'	2:1	2.5'	Channel	Streambank protection	$56,000
76	Channel	6'	700'	2:1	4'	Channel	Streambank protection	$31,000
78	Channel	6'	600'	2:1	3'	Channel	Streambank protection	$20,000
101	Channel	19'	1,400'	2:1	4.5'	Channel	Streambank protection	$71,000

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative I   Sub Basin Kelsey Creek Demonstration Area

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
131	Channel	13'	700'	2:1	4'	Channel	Streambank protection	$31,000
132	Channel	18'	2,100'	2:1	4'	Channel	Streambank protection	$94,000
139	Channel	6'	3,400'	1.5:1	3'	Channel	Streambank protection	$104,000
145	Channel	6'	500'	2:1	5'	Channel	Streambank protection	$28,000
146	Channel	6'	1,000'	2:1	2'	Channel	Streambank protection	$22,000
164	Channel	10'	700'	1:1	4.5'	Channel	Streambank protection	$22,000
106	Channel	12'	2,100'	.75:1	6'	Channel	Streambank protection	$80,000
119	Channel	4'	700'	2:1	3'	Channel	Streambank protection	$24,000
127	Channel	20'	4,900'	3:1	3'	Channel	Streambank protection	$233,000
130	Channel	4'	4,800'	1:1	2.5'	Channel	Streambank protection	$85,000
83	Channel	10'	150'	1.25:1	3'	Channel	Streambank protection	$4,000
69	Channel	20'	600'	1.25:1	3'	Channel	Streambank protection	$15,000
85	Channel	4'	1,450'	2.5:1	3'	Channel	Streambank protection	$59,000
87	Channel	7'	700'	1:1	3'	Channel	Streambank protection	$15,000
89	Channel	7'	500'	2:1	3'	Channel	Streambank protection	$17,000
91	Channel	5'	2,700'	2:1	2.5'	Channel	Streambank protection	$76,000
92	Channel	5'	900'	2:1	2'	Channel	Streambank protection	$20,000

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative I Sub Basin Kelsey Creek Demonstration Area

	EXISTING FACILITIES					PROPOSED FACILITIES		
ELEMENT NUMBER	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
96	Channel	10'	2,600'	2:1	7'	Channel	Streambank protection	$157,000
117	Channel	5'	1,200'	.75:1	2'	Channel	Streambank protection	$15,000
166	Channel	10'	400'	.5:1	3'	Channel	Streambank protection	$6,000
94	Channel	20'	400'	0	3'	Channel	Streambank protection	$3,000
75	Channel	2'	1,800'	1:1	1'	Channel	Streambank protection	$13,000

The Estimated Capital Cost for each element includes Contractor profit, engineering, legal and contingencies. In addition, land purchase and severance costs are included where land is required. All costs are based upon June 1973 prices.

Total Estimated Capital Cost: $4,040,000

Round To: $4,000,000

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative II Sub-Basin Kelsey Creek Demonstration Area

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
177	Pipe	18"	1,140'			Parallel Pipe	21"	$41,000
176	Pipe	18"	1,250'			Parallel Pipe	30"	$67,000
174	Channel	2'	500'	1:1	2.5'	Channel	2.5' width 2.5' depth 1:1 side slopes	$1,000
161	Pipe	24"	950'			Parallel Pipe	18"	$29,000
159	Pipe	36"	900'			Parallel Pipe	24"	$37,000
158	Channel	3'	3,100'	1:1	3'	Channel	3' width 3' depth 2:1 side slopes	$9,000
157	Pipe	12"	650'			Parallel Pipe	15"	$16,000
154	Culvert	24"	50'			Replacement Culvert	7' x 2'	$13,000
153	Channel	3'	550'	1:1	3'	Channel	8' width 3' depth 2:1 side slopes	$4,000
152	None					Holding Pond	Larson Lake area outlet control	$30,000
149	Pipe	18"	280'			Parallel Pipe	21"	$10,000
145	None					Holding Pond	Extension of 140	-0-
142	Pipe	36"	40'			Replacement Pipe	54"	$12,000
141	None					Holding Pond	Extension of 140	-0-
140	None					Holding Pond	25 AF	$127,000
137	Pipe	42"	24"			Replacement Pipe	66"	$13,000
136	None					Holding Pond	6.8 AF	$99,000

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative II Sub-Basin Kelsey Creek Demonstration Area

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
134	Pipe	18"	160'			Parallel Pipe	27"	$13,000
130	Channel	2'	1,800'	2:1	2'	Channel	Flood-plain zone	-0-
129	Channel	3'	6,400'	1:1	1.5'	Channel	Flood-plain zone	-0-
126	None					Holding Pond	4.7 AF	$53,000
122	Pipe	24"	100'			Parallel Pipe	21"	$4,000
118	Pipe	36"	72'			Parallel Pipe	27"	$3,000
119	Channel	4'	700'	5:1	3'	Holding Pond	.6 AF Flood-plain zone	-0-
111	Pipe	21"	1,550'			Parallel Pipe	12"	$31,000
105	Channel		1,200'	No defined channel			Flood-plain zone	-0-
102	Pipe	18"	400'			Parallel Pipe	21"	$14,000
101	Channel	19"	1,400'	2:1	4.5'		Flood-plain zone	-0-
96	Channel	10'	2,600'	2:1	7'		Flood-plain zone	-0-
95	Channel	40'	3,900'	1:1	3.5'		Flood-plain zone	-0-
90	Pipe	24"	75'			Parallel Pipe	30"	$4,000
86	Pipe	48"	60'			Parallel Pipe	48"	$13,000
82	Pipe	48" rough	370'			Pipe	48" smooth	$41,000
78	Channel	6'	600'	2:1	3'		Flood-plain zone	-0-

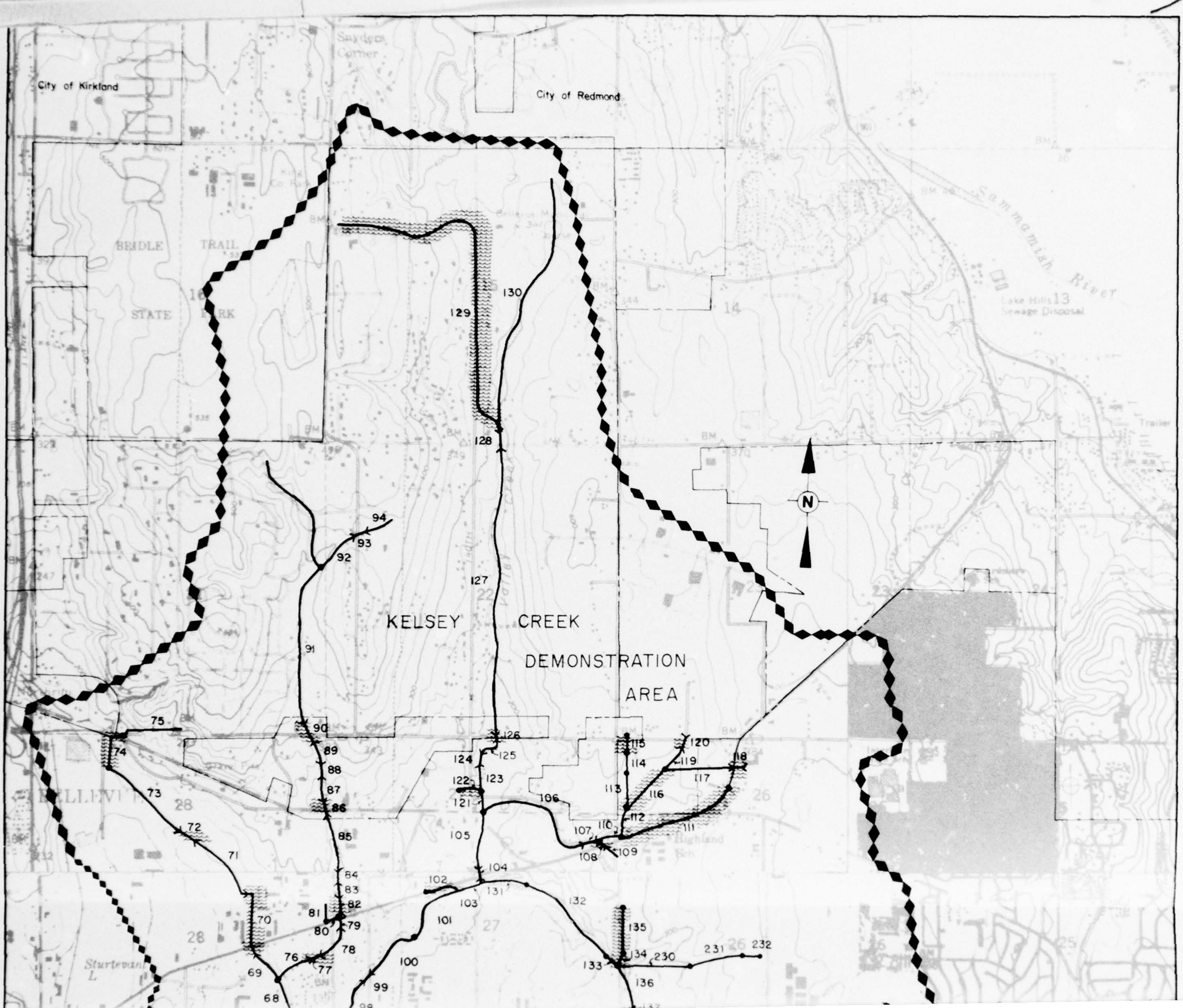
RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

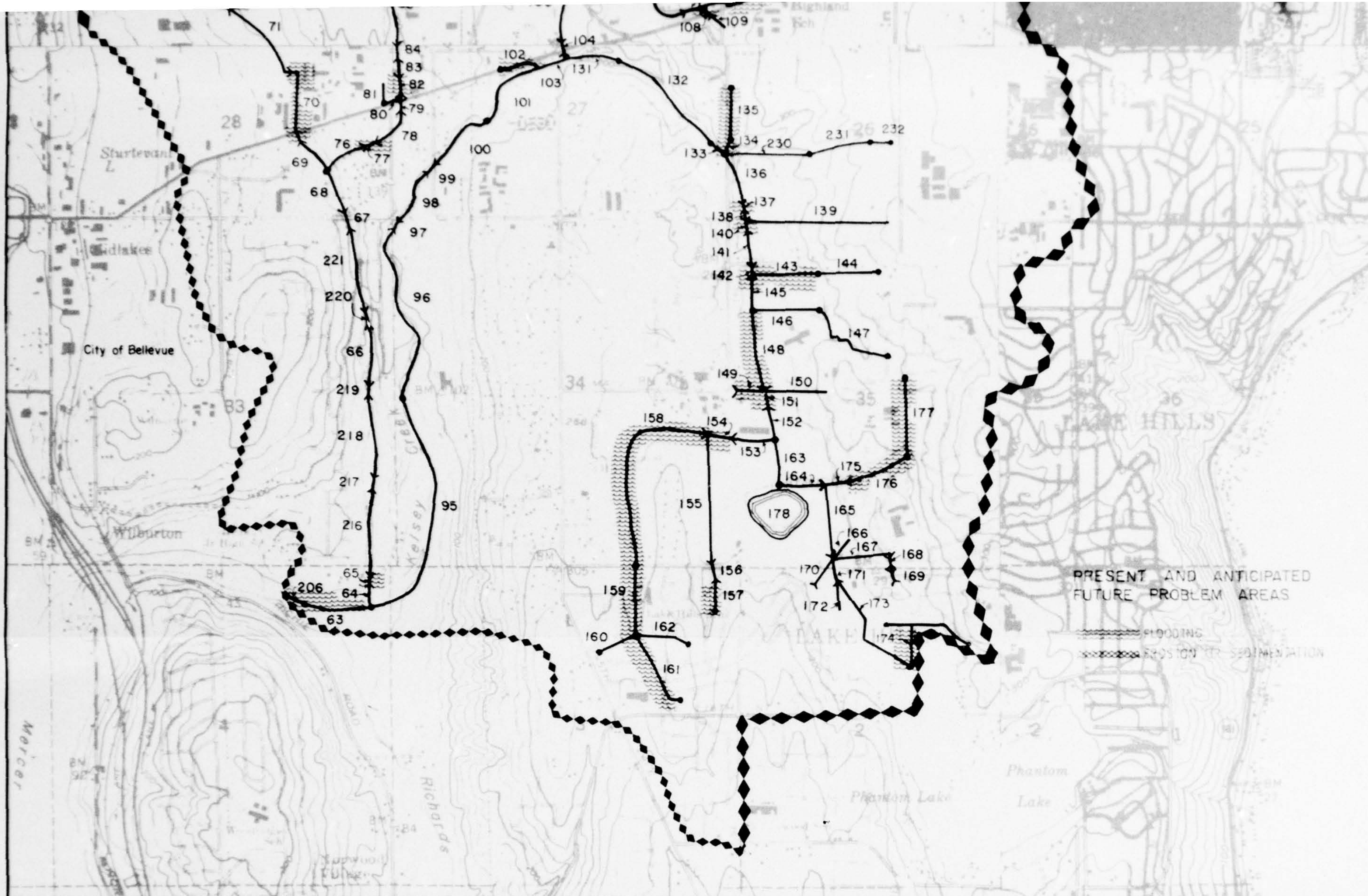
Alternative II   Sub Basin Kelsey Creek Demonstration Area

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
77	Pipe	21"	40'			Replacement Pipe	42"	$9,000
76	Channel	6'	700'	2:1	4'		Flood-plain zone	-0-
74	Pipe	36" rough	700'			Replacement Pipe	36" smooth	$51,000
73	Channel	8'	2,000'	2:1	2.5'		Flood-plain zone	-0-
72	Pipe	48"	60'			Replacement Pipe	54"	$14,000
71	Channel	20'	1,400'	2:1	8'	Holding Pond	10.4 AF	$79,000
68	Channel	6'	900'	4:1	8'	Holding Pond	Flood-plain zone 2.5 AF	$38,000
218	Channel	8'	1,650'	0	2'		Flood-plain zone	-0-
216	Channel	15'	1,000'	1:1	2'		Flood-plain zone	-0-
64	Channel	10'	400'	1:1	2'		Flood-plain zone	-0-
63	Channel	30'	1,000'	4:1	3'		Flood-plain zone	-0-

The Estimated Capital Cost for each element includes Contractor profit, engineering, legal and contingencies. In addition, land purchase and severance costs are included where land is required. All costs are based upon June 1973 prices.

Total Estimated Capital Cost: $875,000
Round To: $900,000


City of Kirkland
City of Redmond
Snyders Corner
BRIDLE TRAIL STATE PARK
Sammamish River
Lake Hills Sewage Disposal
Trailer
N
KELSEY CREEK DEMONSTRATION AREA
Highland
Sturtevant L
68
69
70
71
72
73
74
75
76
77
78
79
80
81
82
83
84
85
86
87
88
89
90
91
92
93
94
99
100
101
102
103
104
105
106
107
108
109
110
111
112
113
114
115
116
117
118
119
120
121
122
123
124
125
126
127
128
129
130
131
132
133
134
135
136
230
231
232



LEGEND

- SUB-BASIN BOUNDARY
- EXISTING CHANNEL
- EXISTING CONDUIT
- MANHOLE, INLET, OR JUNCTION
- CHANNEL OR CONDUIT DESIG.
- CITY LIMITS
- COUNTY (METRO) BOUNDARY
- LEVEE
- CULVERT
- HOLDING POND OR LAKE

1/2 1/4 0 1
MILES

1000 500 0 4000
FEET

NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

MERCER SLOUGH

KELSEY CREEK DEMONSTRATION AREA

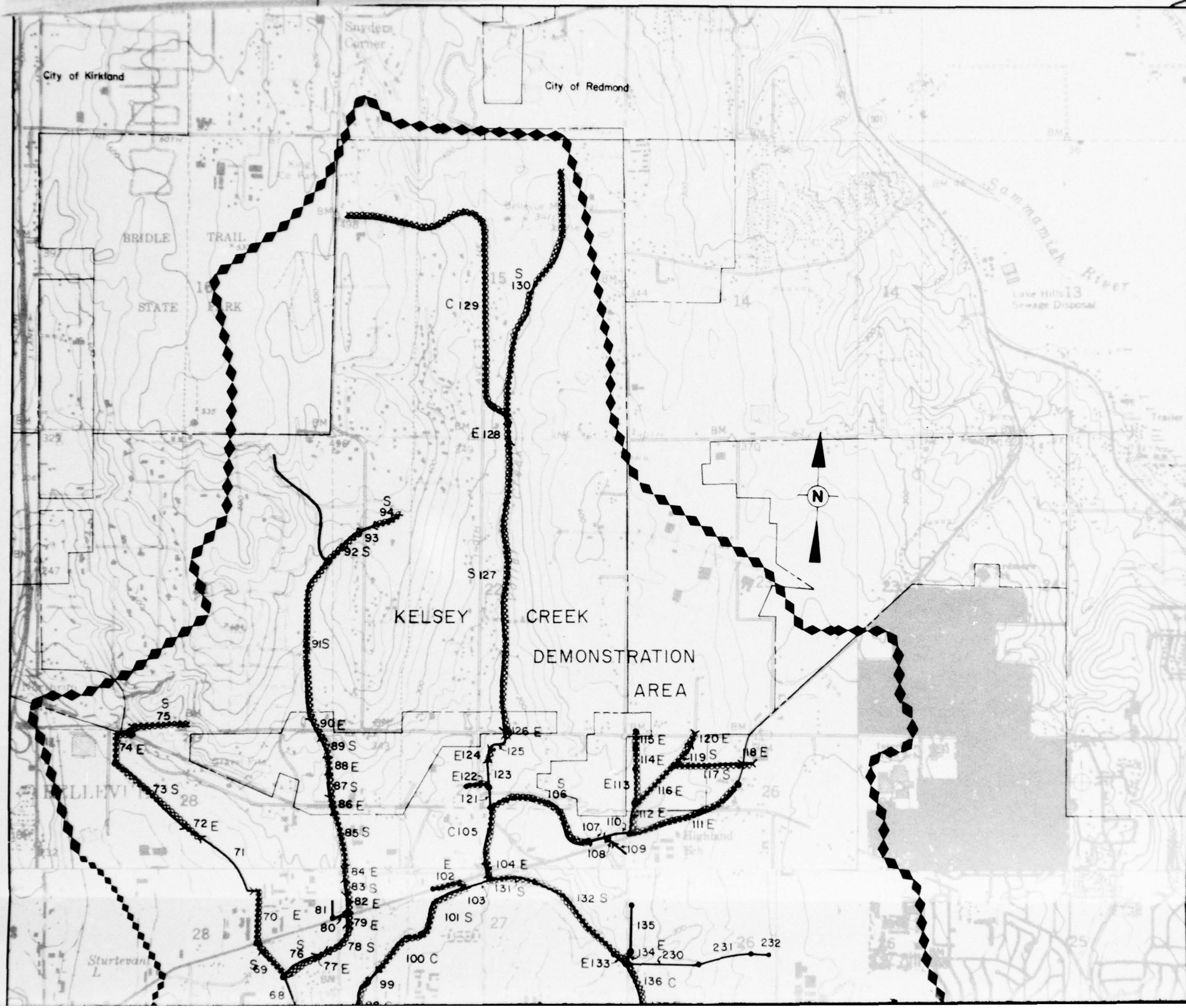
PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

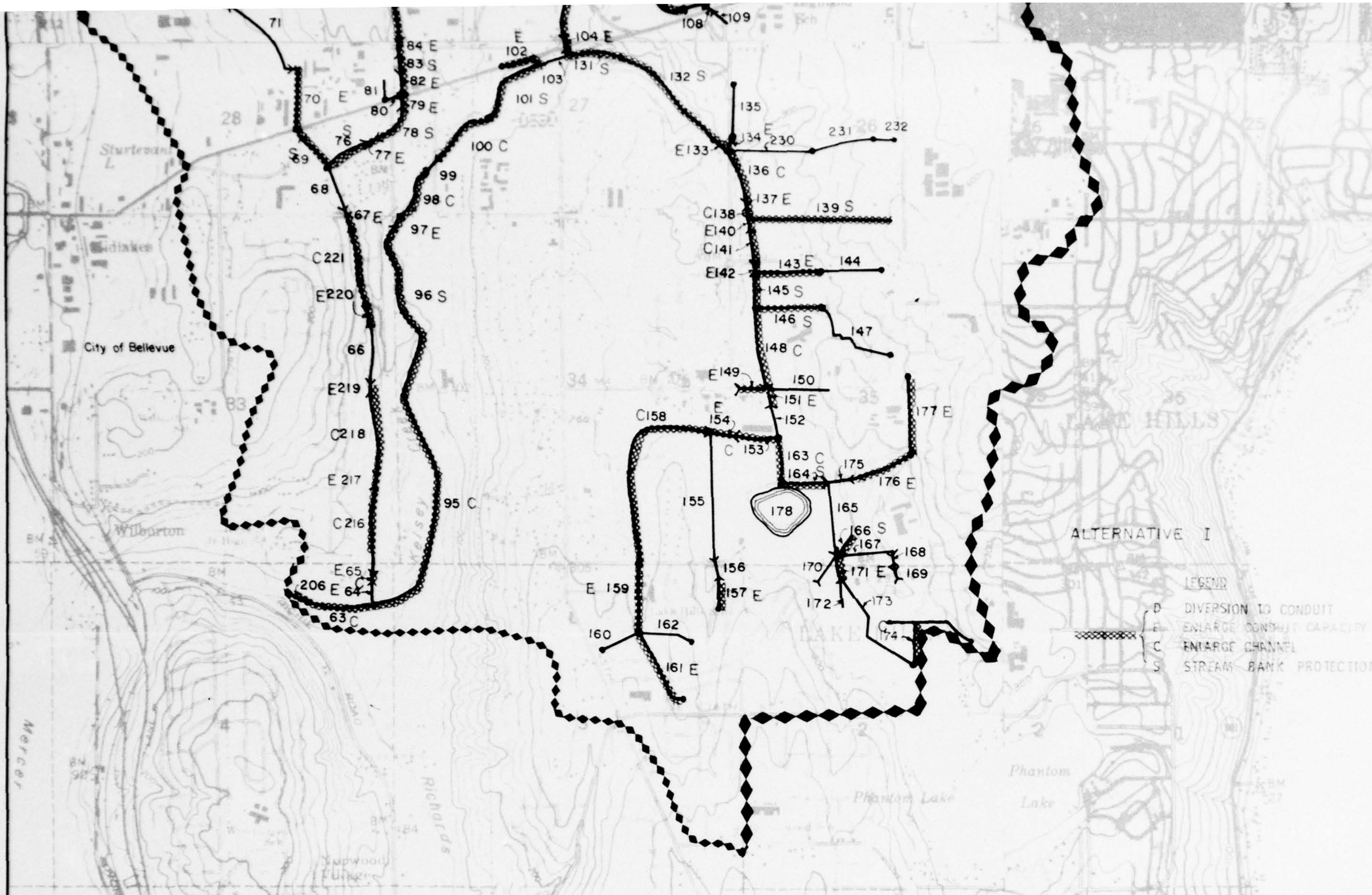
KRAMER, CHIN AND MAYO, INC.
WATER RESOURCES ENGINEERS, INC.
YODER, TROTTER, ORLOB & ASSOCIATES

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO. E*26.1.161 SHEET 1 OF 1

2


City of Kirkland
City of Redmond
Snyders Corner
BRIDLE TRAIL STATE PARK
Sammamish River
Lake Hills Sewage Disposal
Trailer
KELSEY CREEK DEMONSTRATION AREA
N
Highland Sch
Sturtevant L
C 129
S 130
E 128
S 127
S 94
93
92 S
91S
90 E
89 S
88 E
87 S
86 E
85 S
84 E
83 S
82 E
81
80
79 E
78 S
77 E
S 76
S 69
68
70
E
71
72 E
73 S
74 E
S 75
126 E
125
E124
E122
123
121
C105
104 E
E 102
103
131 S
101 S
100 C
99
S 106
E113
107
110
108
109
115 E
114E
116 E
112 E
111 E
120 E
119 S
117 S
18 E
132 S
135
E133
134 E
230
231
232
136 C



LEGEND

SUB-BASIN BOUNDARY
EXISTING CHANNEL
EXISTING CONDUIT
MANHOLE, INLET, OR JUNCTION
CHANNEL OR CONDUIT DESIG.
CITY LIMITS
COUNTY (METRO) BOUNDARY
LEVEE
CULVERT
HOLDING POND OR LAKE

MILES: 1/2, 1/4, 0, 1

FEET: 1000, 500, 0, 4000

NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

MERCER SLOUGH

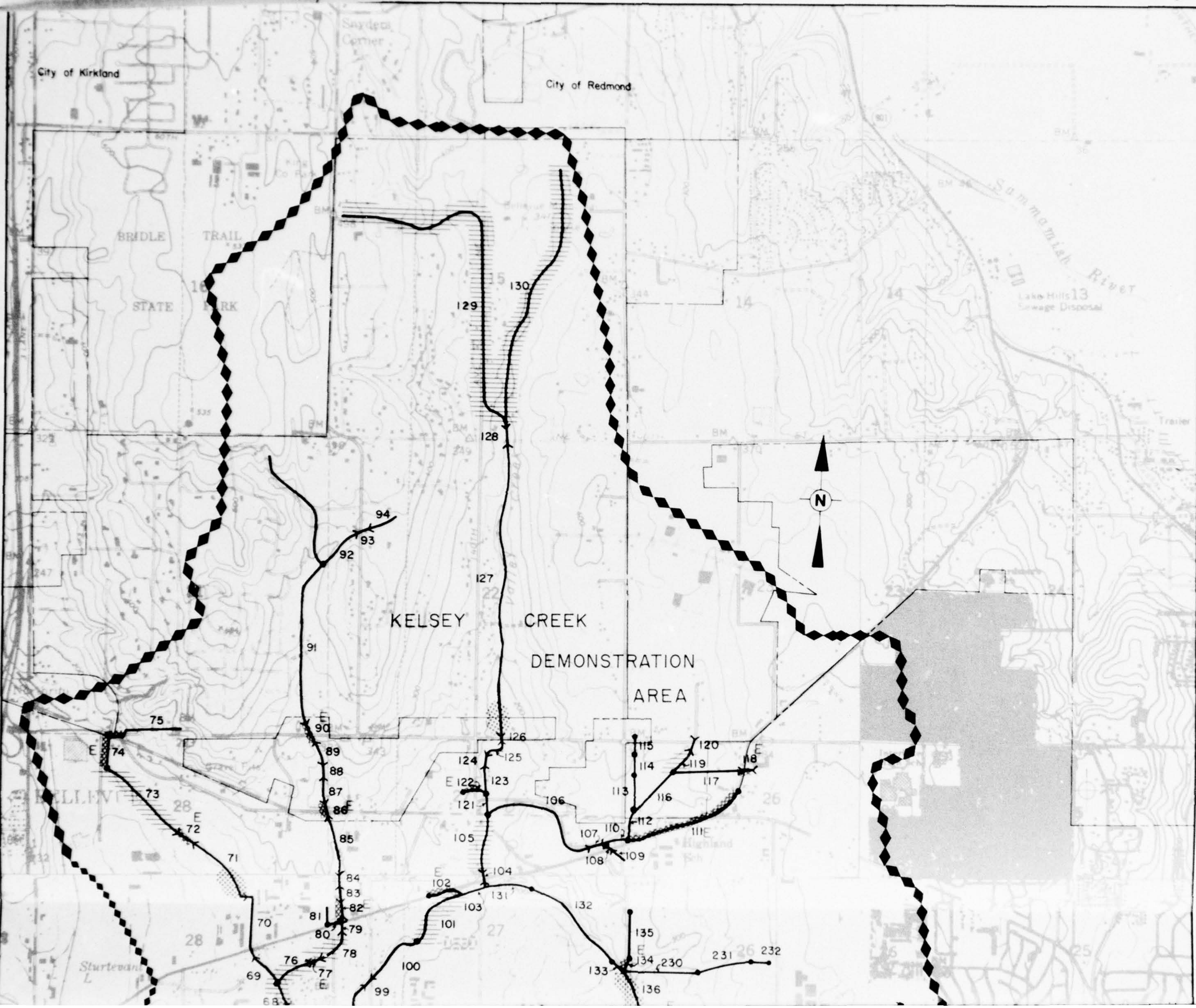
KELSEY CREEK DEMONSTRATION AREA

PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

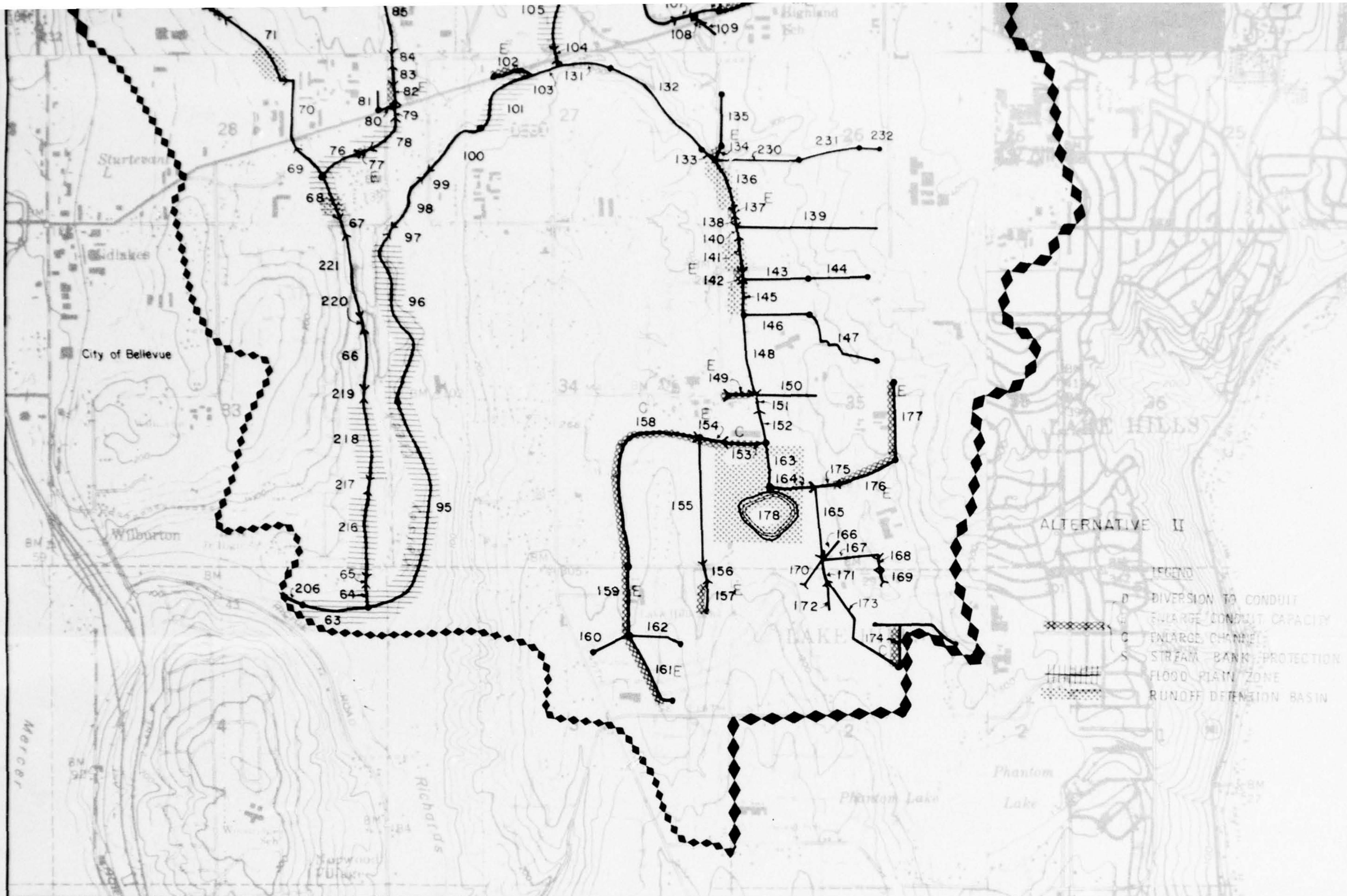
KRAMER, CHIN AND MAYO, INC
WATER RESOURCES ENGINEERS, INC
YODER, TROTTER, ORLOB & ASSOCIATES

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO E.26.1.161 SHEET 10 OF 1



City of Kirkland
City of Redmond
BRIDLE TRAIL STATE PARK
Sammamish River
Lake Hills Sewage Disposal
KELSEY CREEK DEMONSTRATION AREA
N
Highland Sch
Sturtevant L



LEGEND

SUB-BASIN BOUNDARY	
EXISTING CHANNEL	
EXISTING CONDUIT	
MANHOLE, INLET, OR JUNCTION	
CHANNEL OR CONDUIT DESIG.	5
CITY LIMITS	
COUNTY (METRO) BOUNDARY	
LEVEE	
CULVERT	
HOLDING POND OR LAKE	

1/2 1/4 0 1
MILES

1000 500 0 4000
FEET

NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

MERCER SLOUGH

KELSEY CREEK DEMONSTRATION AREA

PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

KRAMER, CHIN AND MAYO, INC.
WATER RESOURCES ENGINEERS, INC.
YODER, TROTTER, ORLOB & ASSOCIATES

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO E-26-1-161 SHEET 1C OF 1

REGIONAL SUB-BASIN C-16

MAY CREEK DEMONSTRATION AREA

GENERAL DESCRIPTION

The May Creek Sub-Basin is located between the City of Renton and Newport Hills, a residential community located about three miles north of Renton. The sub-basin extends southeast from Lake Washington approximately six miles. The direction of flow in the creek is almost continually to the northwest, originating from Lake Kathleen and terminating in Lake Washington.

The geography of the sub-basin is varied with steep upland areas, a broad upland stream valley floor in the central portion, and a very steep lower reach descending to a delta at Lake Washington. The sub-basin boundary is delineated by natural features, such as ridgelines and mountain saddles, rather than man-made features such as levees or roads and buildings.

May Creek is the only principal stream and extends through the entire length of the sub-basin. The Creek may be broadly classified as a boulder zone in its middle and lower reaches. Several tributaries enter the Creek throughout its passage from lake to lake.

Stream	Category	Drainage Area	Discharge
May Creek	III	13 sq. mi.	Lake Washington

The upper May Creek Sub-Basin is mostly undeveloped, at present, with large wooded areas and limited rural-residential uses. The present development becomes more urban as one progresses from the upper sub-basin reaches downstream towards Lake Washington. This characteristic is dominant in the lower basin for the first two miles upstream from Lake Washington, where the residential and commercial developments exist in the City of Renton and the community of Kennydale.

The Creek passes through an industrial area west of Interstate 405 at its mouth. A small percentage of the land is devoted to multiple-family residential, highly industrial and institution uses (e.g. governmental and educational).

The table below shows the percentage of land uses by types for the May Creek Sub-Basin during 1970-72 and those projected for the year 2000 in the Corridor and Comprehensive Plans prepared by the Puget Sound Governmental Conference. It should be noted that the increased use for family purposes will come from present unused lands or lands used for agricultural purposes.

PERCENT OF SUB-BASIN AREA IN SPECIFIED LAND USES

Land Uses	Existing (1970-72)	P.S.G.C. Land Use Projection Comprehensive	Corridor
Single Family	20	40	40
Multiple Family		2	2
Commercial/Services	1	1	1
Govt. and Educ.		1	1
Industrial		1	1
Parks/Dedicated Open Spaces	5	5	5
Agriculture	10	5	5
Airports, Railyards, Freeways, Highways			
Unused Land	63	44	44
Water	1	1	1
Total	100	100	100
Total Impervious Area	5	15	15

NATURE OF EXISTING DRAINAGE SYSTEM

The existing drainage system may be classified as a natural flowing stream. May Creek has man-made features only at roadway and railway crossings (culverts, bridge piers, abuttments, wing wall section). Two small lakes are part of the upper sub-basin: Lake Kathleen, located at the source of May Creek, and Lake Boren, at the source of a small northern tributary.

May Creek has a genuine urban amenity potential for man and as a habitat for wildlife. It is one of the few streams near an industrial complex and urban area that can still be preserved in about its natural state. However, there are sections of the stream that are "trashy" because a few unconcerned individuals use it as a dumping place. This area is not presently serviced by sanitary sewers though it is within the Metro service area.

DRAINAGE PROBLEMS

Two major drainage problems exist within the May Creek Sub-Basin. There is ponding and overbank flooding in the upper and middle reaches of the Creek and erosion and sedimentation in the lower reaches of the Creek and in the middle sections of the upper reaches. Stream flooding begins at 148th Ave. S.E. and extends eastward to the Renton-Issaquah Road. The valley is extremely flat and its soil drains poorly. The flood plain is

presently used primarily for livestock pasture. Therefore, no major damage occurs here in the flood season. There are no buildings within the flood plain area at this time.

Erosion and sedimentation occur downstream of the Coal Creek Parkway on May Creek and downstream of the Renton-Issaquah Road on Honey Creek. A natural erosion process will occur on May Creek, even without urbanization, but the problem has been intensified somewhat by uncontrolled discharge of storm drains at the top of the natural system and by generally increased runoff flows from impervious urban development. These higher runoff rates have accelerated the erosion process.

The eroded material, estimated at 3,000 cubic yards annually, is deposited in the lower reach of May Creek, just before it enters Lake Washington. It forms a delta that is detrimental to the planned use of the area.

Both the 2000 Comprehensive and Corridor Land Use Plans indicate a general urbanization of May Creek. The results of hydrologic analysis indicate no significant difference between the Comprehensive and Corridor Land Use Plans. Therefore, the drainage alternatives presented herein are applicable to both plans. The existing drainage problems will become more severe because of increases in impervious areas and faster runoff. The total impervious area in this sub-basin, under either land use projection, will increase from the existing 5% level to approximately 15%, as shown in the table of projected land uses.

Computer simulation of future runoff conditions, based upon the Comprehensive land use model, indicates that there will be increased overbank flooding and ponding in the pastoral zone of May Creek, and increased velocity and volume of water reaching the steeper lower portion of May Creek prior to entering Lake Washington. This latter problem will accelerate bank erosion and sedimentation transport and deposition at Lake Washington.

Damages that would occur, considering the existing drainage control system and future accelerated runoff conditions of the year 2000, are estimated to total approximately $17,000 per year. These damage costs are reflective of additional sedimentation deposits at the mouth of May Creek, as well as residential and crop inundation.

BASIC ISSUES AND STATUS OF DRAINAGE PLANNING

Presently, the two agencies that have urban drainage planning authority in the May Creek Sub-Basin are King County and the City of Renton. King County created a flood control zone district for May Creek, but the district was later dissolved by a petition and vote of the residents within the district who objected to the proposed assessment levels.

At present, there are no specific drainage planning proposals for the sub-basin, other than those set forth hereafter in this report. However, the entire sub-basin is one of the five demonstration areas of the RIBCO Study and as such, the drainage problems here have been presented

to and discussed by the residents of the sub-basin. At a public meeting on November 1, 1974, the local residents expressed opinions on the following five drainage concepts which were presented to them; 1) continuation of present trends, 2) storm water diversion, 3) flood plain management, 4) channelization (enlarging May Creek), and 5) watershed management (develop runoff controls).

The consensus of opinion of those present was that only two alternatives should be considered, namely, channelization of May Creek and control of runoff from future development. Storm water diversion and flood plain management were discussed, but not given sufficient support by the residents present. Continuation of existing trends in drainage control or the lack of it was deemed unacceptable.

Staff members from the King County Public Works Department, Hydraulics Division, and representatives of the citizen group in the May Creek Sub-Basin have also jointly reviewed the initial alternative plans for drainage developed by this RIBCO Study for May Creek Sub-Basin.

ALTERNATIVE PLANS FOR PROPOSED DRAINAGE CONTROL

The existing drainage system of May Creek Sub-Basin as described by local agencies was evaluated by computer simulation applying the region's 10-year storm to P.S.G.C. year 2000 land use. Drainage problems thus identified were analyzed and possible solutions provided in development of alternative plans for drainage control as described herein.

Two major alternative plans were studied for solving May Creek drainage problems, the first using drop structures and channelization and the second being a combination of drop structures and runoff control features.

ALTERNATIVE PLAN I

General Concept

The general concept of Alternative Plan I is to increase the capacity of the Creek by 1) channelization of the upper reaches to relieve the flooded area there, and bank protection in the upper-middle section to reduce erosion, and 2) construction of drop structures in the lower reaches to decrease erosion and sedimentation. This alternative would relieve all existing flow restraints, thereby increasing peak runoff. Control of runoff from future development would not be required.

Major Features

The major effort in the Creek's upper reaches would be clearing and widening of the channel. This would be done generally from above the Renton-Issaquah Road down to 148th Ave. S.E. Bridges and culverts along the Creek would be enlarged, so the predicted flows could pass without causing backwater conditions. The stream's midsection in the upper sub-basin would require bank protection to decrease erosion which would otherwise result from the increased volume and velocity of water. The soils in this area are easily eroded at low velocities. Bank

protection would also be required from above 16th Avenue S.E. at Coalfield to 800 feet above 148th Avenue S.E. and again below 144th Avenue S.E.

The major feature of Alternative Plan I in the lower reaches is the construction of drop structures to dissipate energy and lower stream velocities in order to control erosion. The type of drop structure being considered is a rock-wall wier made of rip-rap material. Drop structures would be required from above the confluence of May Creek and Lake Boren's outlet to above Interstate 405. Dr. Milo Bell, a local fisheries expert working with local property owners, has suggested the use of low-head drop structures one foot high in order to facilitate fish passage. This criteria has been used as a guide.

Bank protection would be required on a portion of the outlet from Lake Boren. Minor channel enlargement would be required at the Lake Boren outlet. This is considered a local problem.

Cost

The total cost of major stream improvements is estimated at $1,600,000.

ALTERNATIVE PLAN II

General Concept

Alternative Plan II would consist of watershed management techniques supplemented by some structural installations. This alternative envisions detaining runoff on-site and along the system where practicable. Streamside activity would be controlled through zoning. Drop structures in the stream's lower reach would be required to provide erosion protection.

Major Features

Alternative Plan II consists of the following major elements. All future development sites throughout the entire watershed would be required to have runoff control to control peak runoff to not more than 25% above existing conditions. This would reduce peak runoff in developing areas to near natural levels. The major portion of the upper reach, adjacent to the stream, would be flood-plain zoned; land use would remain as agricultural or open space. Recreational uses or public open space, among other alternative land uses, would be compatible with this zoning.

One holding pond would be constructed at 148th Ave. S.E. with approximately 16-acre feet of storage. This facility would reduce discharge during major storms to a lower rate than would be experienced from the stream in an uncontrolled condition and hold water for controlled release at a later time. The holding pond also will provide limited groundwater recharge. Drop structures similar in type and location to Alternative Plan I would be used to control erosion. These drop structures could be eliminated if the natural erosion rate in the stream was acceptable to streamside property owners.

Cost

The total estimated capital cost for this alternative is $600,000.

PEAK FLOW COMPARISONS

The following table indicates 10 year peak flows under existing facilities and land use, and under alternative drainage management solutions for the year 2000. The peak flows are given for portions of the Creek in the upper pasture reaches, as well as at the point of discharge into Lake Washington.

COMPARISON OF 10 YEAR PEAK FLOWS
(Cubic Feet Per Second)

	Existing Land Use			
Location	Existing* Facilities	Existing* Facilities	Alternative Plan I	Alternative Plan II
Lake Washington	280	500	650	350
148th Ave. S.E.	100	360	490	115
176th Ave. S.E.	60	150	380	131

*Flows limited by existing system capacity.

ENVIRONMENTAL ASSESSMENT OF ALTERNATIVE PLANS

Field inspections were made of the suggested alternatives for this sub-basin. This process was followed throughout the RIBCO Study in developing alternative plans for the various regional sub-basins. The inspections were based on the alternative evaluation procedure which identified 34 unique criteria grouped in general categories as follows: 1)Effectiveness, 2) Human Values, 3) Environmental Factors, 4) Implementation, and 5) Resource Requirements.

The various structural solutions were checked against the appropriate criteria. The various non-structural solutions were reviewed for their relationship to existing and probable future developments. The criteria rating total for Alternative Plan I, which employs channelization in the upper and middle reaches and drop structures in the lower reaches, was a minus 26 on a scale ranging from positive 108 to negative 108. The total evaluation rating for Alternative Plan II, which employs runoff control, storage in the upper basin and drop structures in the lower reaches, was a plus 36.

Both alternatives were judged to be effective in controlling drainage. Both plans involved certain sacrifices of human value and human uses within the sub-basin if the systems were built. Environmentally, Alternative Plan II clearly offered more resource preservation potential than Alternative Plan I, which required the channelization of the entire

pastoral flood plain of the stream. Neither alternative is part of present planning of either of the involved agencies and therefore extensive cooperative effort on their parts is required before either plan can be realized. Both of the alternatives involve commitments of the use and management of natural resources because they rely on certain structural treatments for all or part of their solutions. Therefore, neither alternative can be said to be clearly superior to the other in this concern. They involve choices of concerned citizens.

One critical element of both alternatives is the proposal to use drop structures in the ravines of the lower reaches of May Creek. The care in which these structures are located and designed and the disruption which can effect natural resources will be key factors in determining their overall acceptance and effectiveness in controlling erosion and sedimentation and preserving the ecology of the stream.

Alternative Plan II relies on flood plain zoning and runoff control from future land development. This treatment combination, if it is to be part of the chosen alternative, should be implemented as an early organized effort. Any portion of the sub-basin that develops without these combined controls will require more structural treatment than Alternative Plan II can accommodate. This issue should be brought to the attention of all citizens and their local agencies.

There are also other sacrifices which are involved in the two alternatives. Alternative Plan I allows development within most of the pastoral flood plain, whereas Alternative Plan II requires that this area be flood-plain zoned which would effectively remove the areas so designated from any future intensive land uses typical of urbanized areas.

CONCLUSIONS

Alternative Plan II is clearly superior to Alternative Plan I, because of the relatively undeveloped nature of the sub-basin, but does require immediate action to protect and preserve the natural values. As pointed out above, this action would require runoff control at or near existing rates for any new development. It also requires designation of the pastoral zone of the stream as a flood plain.

King County and the City of Renton should establish an effective agreement on a master drainage plan, incorporating the conditions of Alternative Plan II. Both agencies should then move to implement and enforce the required runoff controls and flood plain zoning within their own jurisdiction.

It is pointed out here, that the basic issue is which local agency or agencies will have jurisdiction and responsibility for control of urban drainage and related flood damage problems. There is also the issue of the use or extent of use of land use zoning control methods by and between the City of Renton and King County. The County should have the responsibility for control of drainage and flood damage, and the City and County should have control of zoning, including flood plain zoning within their respective boundaries, and concurrent jurisdiction in outer fringe

areas of the City. This may require some amendments to the State Laws and local ordinances.

EARLY ACTION

In addition to the immediate need for development of a drainage master plan and designation of jurisdictional leadership within this demonstration area, certain physical features of the alternative plans, presented herein, appear to be generally applicable to any drainage plan which may be forthcoming as well as both suitable and desirable for early implementation within the next 10 year period.

FACILITY RECOMMENDATIONS

The overall recommendation for May Creek is that of preserving the natural drainage system. May Creek residents must decide upon which alternative they want to follow. However, prior to making that decision, design and construction could proceed for the following elements:

Category I - Common Alternative Elements

Streambank protection and/or drop structures to protect those critical or severe erosion areas along May Creek downstream of Element 42.

Estimated Capital Cost - $100,000.

Category II - Alternative Elements Common in Scope

Element Number		Alternative II Estimated Capital Cost		Alternative I Estimated Capital Cost
30	Single 6' x 4' box	$19,000	Triple 6' x 4' box	$27,000 for additional 2 barrels

Category III - Response to Reported Drainage Problems

None in addition to those reported in Category I.

EVALUATION MATRIX

MAY CREEK DEMONSTRATION AREA

ALTER-NATIVES	SUB TOTAL	EFFECTIVENESS: Use of existing facilities	System reliability	System maintainability	System flexibility	Flood damage reduction	Consequences of overcharge	Erosion and sedimentation control	Cost/benefits ranking	SUB TOTAL	HUMAN VALUES: Urban quality (aesthetics)	Effect on land use	Displacement of people	Educational value	Community cohesion	Multiple use potential	Public health and safety	SUB TOTAL	ENVIRONMENTAL FACTORS: High flow conditions	Alteration of natural system	Effects on groundwater	Low flow conditions	Water quality	Construction disruption	Effects on wildlife	Effects on aquatic life	Effects on vegetation	SUB TOTAL	IMPLEMENTATION: Legislative requirements	Jurisdictional	Land acquisition	Public acceptance	Financing	Effects of no action	SUB TOTAL	RESOURCE REQUIREMENTS: Energy	Materials	Land	Capital	RATING TOTAL
		CRITERIA WEIGHT									CRITERIA WEIGHT								CRITERIA WEIGHT										CRITERIA WEIGHT							CRITERIA WEIGHT				
		1	4	3	2	4	4	4	2		4	2	2	1	3	3	4		4	4	4	4	4	2	4	4	4		4	4	2	4	4	3		3	3	2	2	
I	+ 5	-1 -1	+1 +4	0	0	+1 +4	0	0	-1 -2	-6	-1 -4	+1 +2	+1 +2	0	-1 -3	-1 -3	0	-18	0	-1 -4	0	-1 -4	0 0	-1 -2	0	-1 -4	-1 -4	+1	0	-1 -4	-1 -2	+1 +4	0	+1 +3	-8	-1 -3	-1 -3	0	-1 -2	-26
II	+17	+1 +1	+1 +4	0	0	+1 +4	+1 +4	+1 +4	0	+1	0	-1 -2	+1 +2	+1 +1	0	0	0	+24	+1 +4	0	+1 +4	+1 +4	+1 +4	0	+1 +4	+1 +4	0	-8	-1 -4	-1 -4	0	0	0	0	+2	0	0	+1 +2	0	+36

RUNOFF QUALITY SUMMARY
MAY CREEK DEMONSTRATION AREA

BASED UPON A 10-YEAR STORM PRECEDED BY 5 DAYS WITH LITTLE OR NO RAINFALL#

LOCATION	ALTERNATIVE PLAN	PEAK FLOW (cfs)	CONCENTRATION AT PEAK FLOW*				
			BOD	TOTAL COLIFORM	NH_3	$NO_2 + NO_3$	PO_4
Lake Washington	Existing Land Use Existing Conditions	280	1	1.0×10^4	.02	.3	.05
	2000 Comprehensive Land Use I	650	1	1.9×10^4	.03	.4	.1
	II	350	.5	$.8 \times 10^4$	.02	.2	.05
Below confluence with Honey Creek	Existing Land Use Existing Conditions	240	.5	$.7 \times 10^4$	.02	.3	.05
	2000 Comprehensive Land Use I	625	1	1.6×10^4	.03	.3	.05
	II	275	.5	$.7 \times 10^4$	.02	.3	.05
Above confluence with Honey Creek	Existing Land Use Existing Conditions	125	1	$.7 \times 10^4$	.02	.4	.05
	2000 Comprehensive Land Use I	550	1	1.0×10^4	.02	.3	.05
	II	175	.5	$.7 \times 10^4$	.02	.3	.05

Less than a total of 0.5 inches of rainfall in any one day.
* Concentrations in mg/liter except total coliform which is in MPN/100 ml.

RUNOFF QUALITY SUMMARY
MAY CREEK DEMONSTRATION AREA

BASED UPON A 10-YEAR STORM PRECEDED BY 15 DAYS WITH LITTLE OR NO RAINFALL#

LOCATION	ALTERNATIVE PLAN	PEAK FLOW (cfs)	CONCENTRATION AT PEAK FLOW*				
			BOD	TOTAL COLIFORM	NH_3	$NO_2 + NO_3$	PO_4
	Existing Land Use						
Lake Washington	Existing Conditions	280	2	3.0×10^4	.05	.8	.1
	2000 Comprehensive Land Use						
	I	650	3	5.7×10^4	.1	1.1	.2
	II	350	2	2.2×10^4	.05	.8	.1
	Existing Land Use						
Below confluence with Honey Creek	Existing Conditions	240	2	2.2×10^4	.05	.8	.1
	2000 Comprehensive Land Use						
	I	625	3	4.7×10^4	.1	1.0	.2
	II	275	2	2.1×10^4	.05	.8	.1
	Existing Land Use						
Above confluence with Honey Creek	Existing Conditions	125	2	2.2×10^4	.05	1.1	.2
	2000 Comprehensive Land Use						
	I	550	2	3.0×10^4	.05	1.0	.2
	II	175	2	2.0×10^4	.05	1.0	.2

Less than a total of 0.5 inches of rainfall in any one day.
* Concentrations in mg/liter except total coliform which is in MPN/100 ml.

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative I   Sub-Basin May Creek

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
15	Channel	8'	7,900'	2:1	2'	Channel	15' width 2' depth 2:1 side slopes	$31,000
56	Channel	10'	2,400'	2:1	2'	Channel	25' width 2' depth 2:1 side slopes	$20,000
28	Channel	6'	900'	4:1	4'	Channel	30' width 4' depth 2:1 side slopes Streambank protection	$51,000
30	Culvert	4.2'	60'	0	3'	Replacement Culvert	18' x 4'	$46,000
14	Channel	15'	1,500'	1:1	4'	Channel	25' width 4' depth 2:1 side slopes Streambank protection	$90,000
31	Channel	18'	850'	.5:1	3'	Channel	40' width 3' depth 2 1 side slopes Streambank protection	$44,000
52	Channel	17'	2,400'	3:1	3.5'	Channel	60' width 3.5' depth 2:1 side slopes Streambank protection	$167,000
51	Bridge	15'	29'	2:1	5'	Bridge	70' width 5' depth 2:1 side slopes	$46,000
50	Channel	17'	2,400'	1:1	4.5'	Channel	40' width 4.5' depth 2:1 side slopes Streambank protection	$190,000
49	Bridge	20'	10'	2:1	5'	Bridge	45' width 5' depth 2:1 side slopes	$10,000
11	Channel	17'	4,000'	1:1	4.5'	Channel	40' width 4.5' depth 2:1 side slopes	$126,000
48	Channel	6'	900'	1:1	4'	Channel	50' width 4' depth 2:1 side slopes	$44,000
47	Bridge	20'	24'	2:1	7'	Bridge	45' width 5' depth 2:1 side slopes	$17,000
46	Channel	6'	500'	1:1	4'	Channel	50' width 4' depth 2:1 side slopes	$25,000
45	Bridge	23'	11'	2:1	7'	Bridge	45' width 5' depth 2:1 side slopes	$17,000
26	Channel	6'	1,000'	1:1	4'	Channel	50' width 4' depth 2:1 side slopes	$49,000
44	Bridge	14'	12'	2:1	7'	Bridge	45' width 7' depth 2:1 side slopes	$19,000

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative I Sub Basin May Creek

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
43	Channel	6'	1,800'	1:1	4'	Channel	17.5' width 4' depth 2:1 side slopes Streambank protection	$103,000
25	Channel	29'	2,000'	1.1	5'	Drop Structure	1' drop 29' base Approx. 50 required	$68,000
7	Channel	15'	2,000'	1:1	10'	Drop Structure	1' drop 15' base Approx. 10 required	$9,000
6	Channel	35'	3,200'	.5:1	3'	Drop Structure	1' drop 35' base Approx. 64 required	$90,000
3	Channel	35'	2,200'	1:1	3'	Drop Structure	1' drop 35' base Approx. 44 required	$68,000
36	Channel	30'	800'	4:1	4'	Drop Structure	1' drop 30' base Approx. 16 required	$36,000
34	Channel	30'	1,500'	4:1	4'	Drop Structure	1' drop 30' base Approx. 15 required	$34,000
29	Channel	30'	3,540'	4:1	4'	Drop Structure	1' drop 29' base Approx. 50 required	$68,000
23	Channel	8'	1,500'	1:1	2.5'	Channel	Streambank protection	$23,000
35	Culvert	10"	32'	0	7'	Bridge Modification	45' width 7' depth 2:1 side slopes	$64,000

The Estimated Capital Cost for each element includes Contractor profit, engineering, legal and contingencies. In addition, land purchase and severance costs are included where land is required. All costs are based upon June 1973 prices.

Total Estimated Capital Cost: $1,555,000
Round To: $1,600,000

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

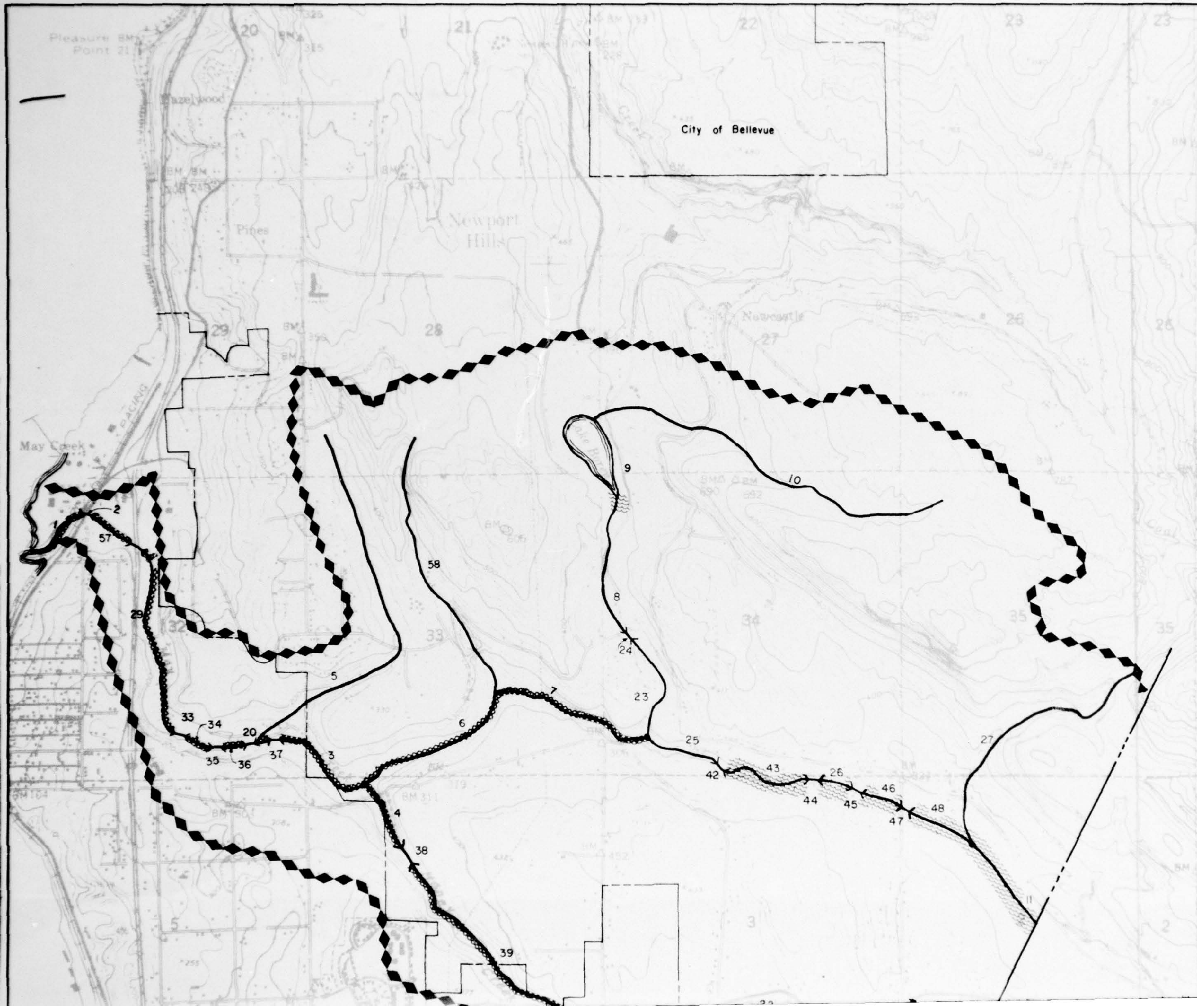
Alternative II   Sub Basin May Creek

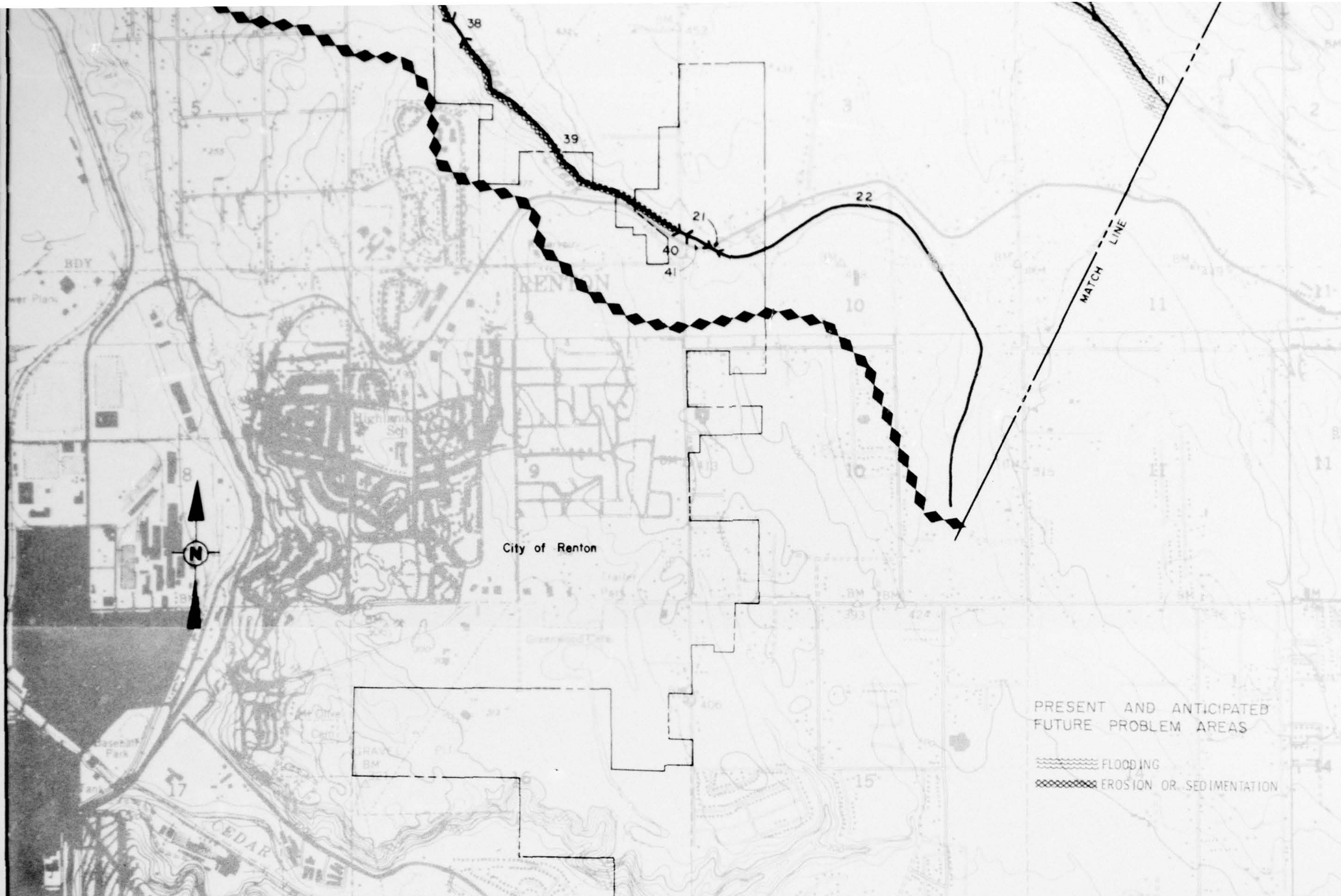
ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
30	Culvert	4.2'	60'	0	3'	Replace-ment Culvert	12' x 3'	$22,000
48	None					Holding Pond	16 AF	$175,000
23	Channel	8'	1,500'	1:1	2.5'	Channel	Streambank protection	$23,000
25	Channel	29'	2,000'	1:1	5'	Drop Structure	1' drop 29' base Approx. 50 required	$68,000
7	Channel	15'	2,000'	1:1	10'	Drop Structure	1' drop 15' base Approx. 10 required	$9,000
6	Channel	35'	3,200'	.5:1	3'	Drop Structure	1' drop 35' base Approx. 64 required	$90,000
3	Channel	35'	2,200'	1:1	3'	Drop Structure	1' drop 35' base Approx. 44 required	$68,000
36	Channel	30'	800'	4:1	4'	Drop Structure	1' drop 30' base Approx. 16 required	$36,000
34	Channel	30'	1,500'	4:1	4'	Drop Structure	1' drop 30' base Approx. 15 required	$34,000
29	Channel	30'	3,540'	4:1	4'	Drop Structure	1' drop 29' base Approx. 50 required	$68,000

The Estimated Capital Cost for each element includes Contractor profit, engineering, legal and contingencies. In addition, land purchase and severance costs are included where land is required. All costs are based upon June 1973 prices.

Total Estimated Capital Cost: $593,000
Round To: $600,000

★ U. S. GOVERNMENT PRINTING OFFICE: 1975—699-304 /35 REGION 10


City of Bellevue
Newport Hills
Newcastle
Pines
Hazelwood
May Creek
Pleasure Point
1
2
3
4
5
6
7
8
9
10
11
20
23
24
25
26
27
29
33
34
35
36
37
38
39
42
43
44
45
46
47
48
57
58



LEGEND

- SUB-BASIN BOUNDARY
- EXISTING CHANNEL
- EXISTING CONDUIT
- MANHOLE, INLET, OR JUNCTION
- CHANNEL OR CONDUIT DESIG. 5
- CITY LIMITS
- COUNTY (METRO) BOUNDARY
- LEVEE
- CULVERT
- HOLDING POND OR LAKE

1/2 1/4 0 1 MILES

1000 500 0 4000 FEET

NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

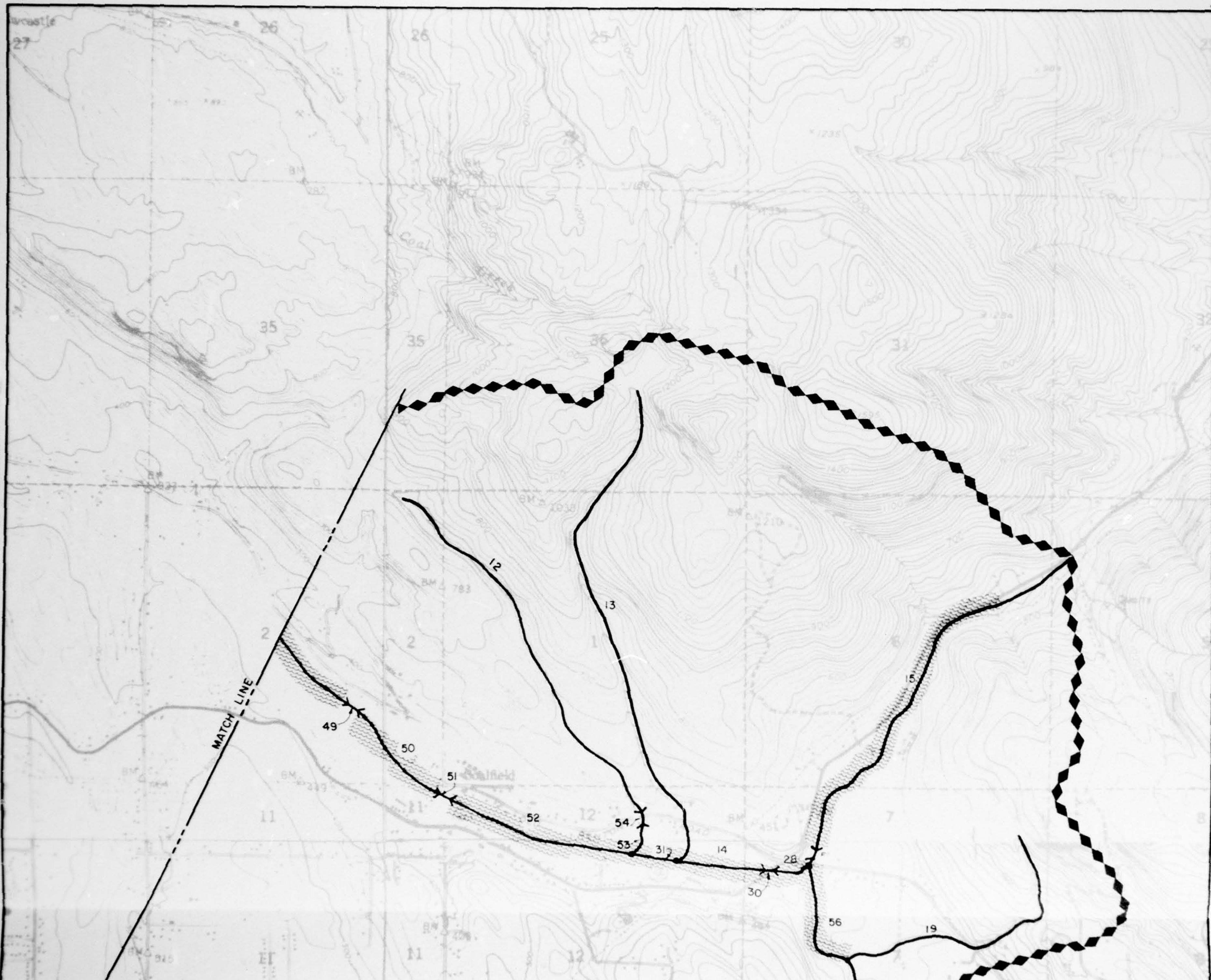
MAY CREEK DEMONSTRATION AREA

PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

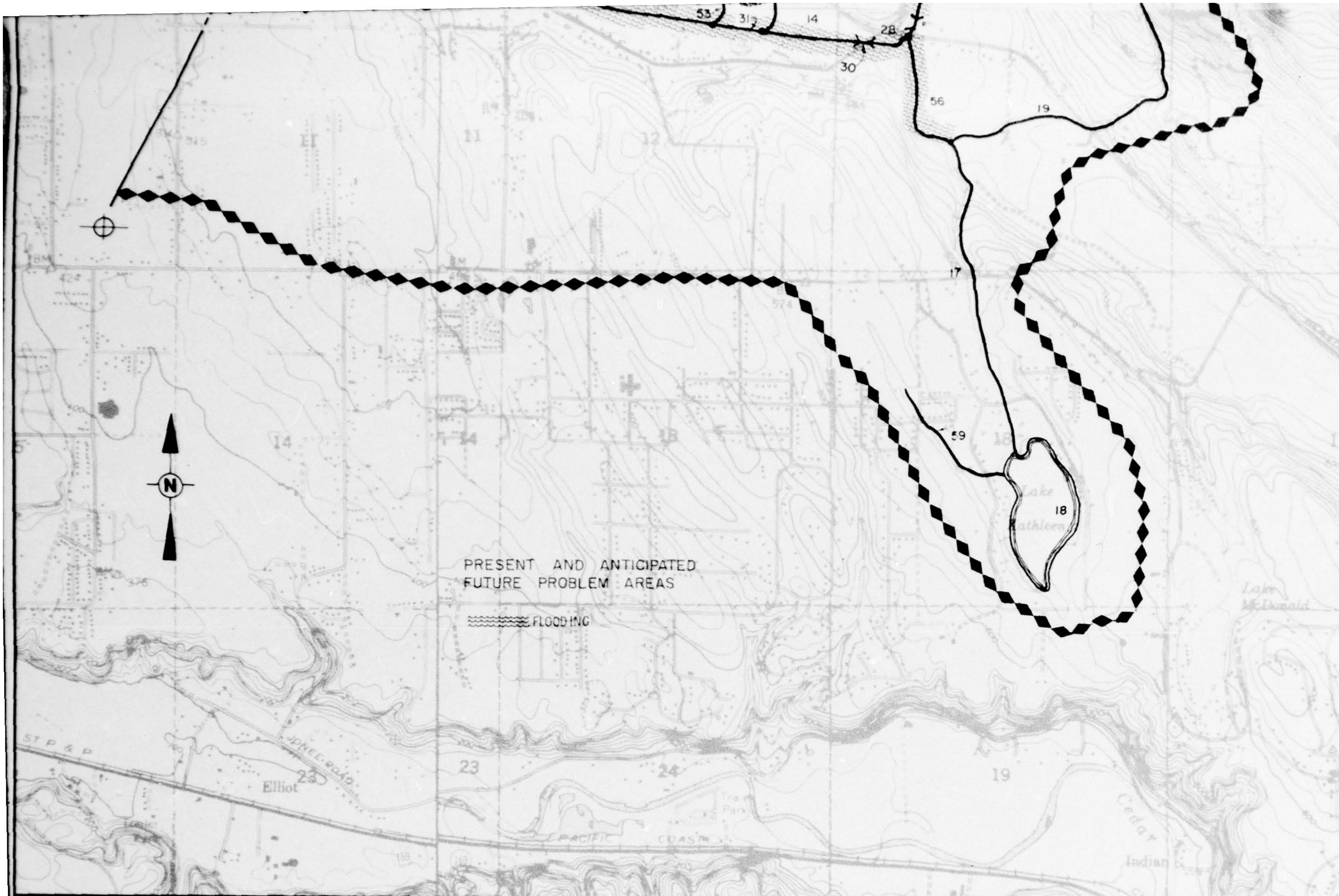
KRAMER, CHIN AND MAYO, INC
WATER RESOURCES ENGINEERS, INC
YODER, TROTTER, ORLOB & ASSOCIATES

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO E-26.1.161 SHEET 1a OF 2



MATCH LINE
12
13
14
15
19
28
30
31
49
50
51
52
53
54
56
Coal Creek



LEGEND

SUB-BASIN BOUNDARY	
EXISTING CHANNEL	
EXISTING CONDUIT	
MANHOLE, INLET, OR JUNCTION	•
CHANNEL OR CONDUIT DESIG.	5
CITY LIMITS	
COUNTY (METRO) BOUNDARY	
LEVEE	
CULVERT	
HOLDING POND OR LAKE	

MILES: 1/2 — 1/4 — 0 — 1

FEET: 1000 500 0 — 4000

NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

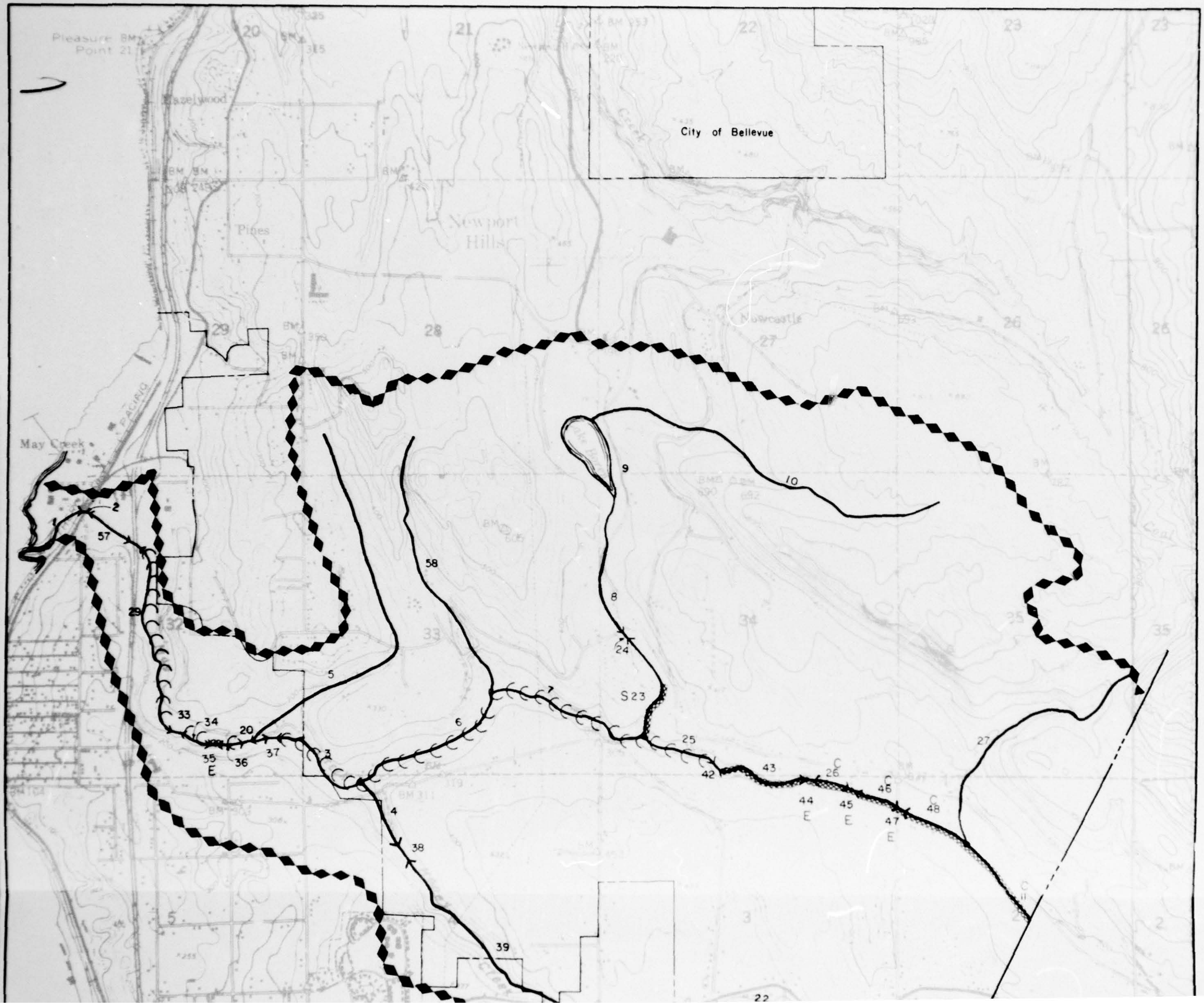
MAY CREEK DEMONSTRATION AREA

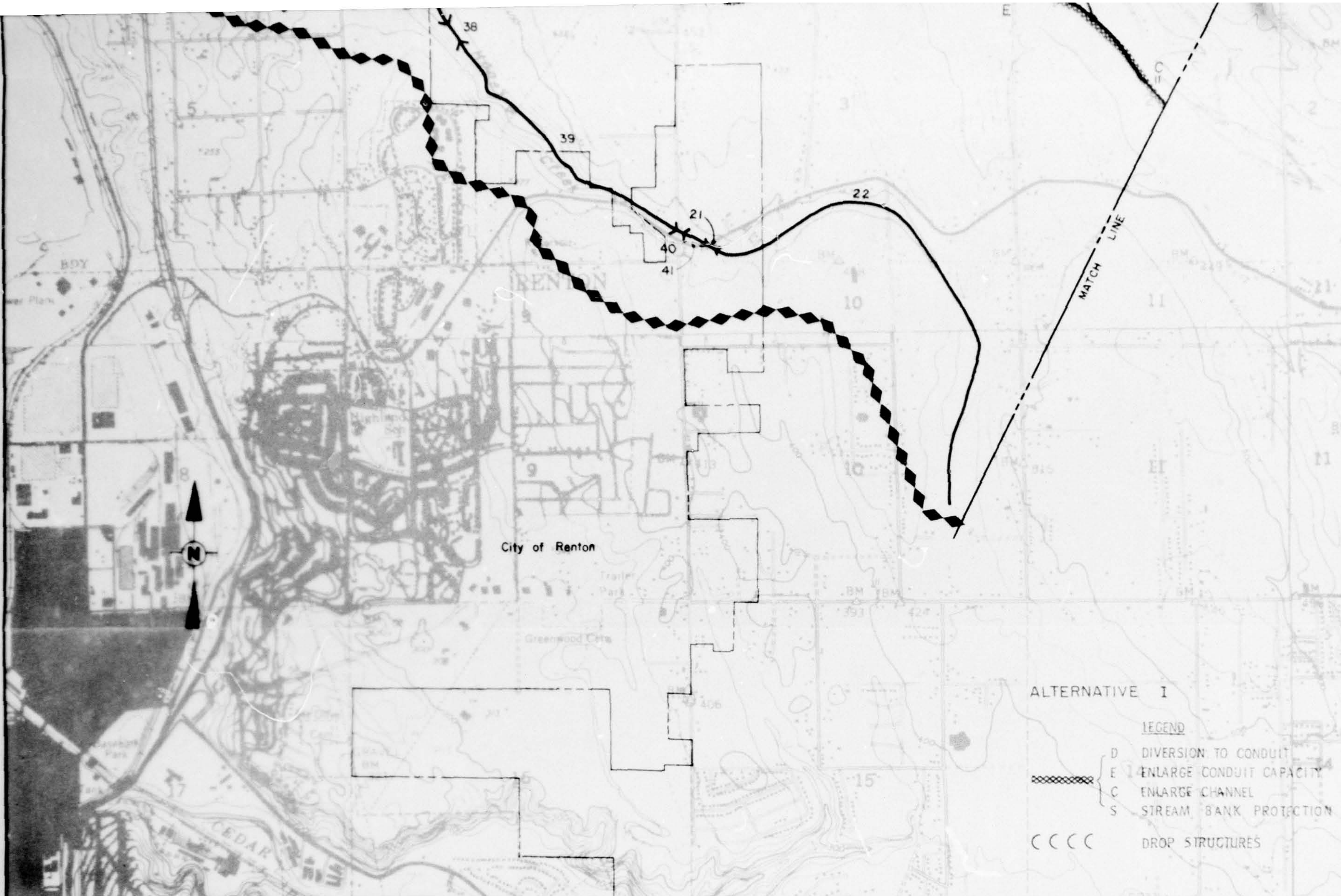
PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

KRAMER, CHIN AND MAYO, INC
WATER RESOURCES ENGINEERS, INC
YODER, TROTTER, ORLOB & ASSOCIATES

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO E-26.1.161 SHEET 2b OF 2


City of Bellevue
Newport Hills
Pines
Hazelwood
Newcastle
May Creek
Pleasure Point



LEGEND

SUB-BASIN BOUNDARY
EXISTING CHANNEL
EXISTING CONDUIT
MANHOLE, INLET, OR JUNCTION
CHANNEL OR CONDUIT DESIG. 5
CITY LIMITS
COUNTY (METRO) BOUNDARY
LEVEE
CULVERT
HOLDING POND OR LAKE

1/2 1/4 0 1
MILES

1000 500 0 4000
FEET

NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

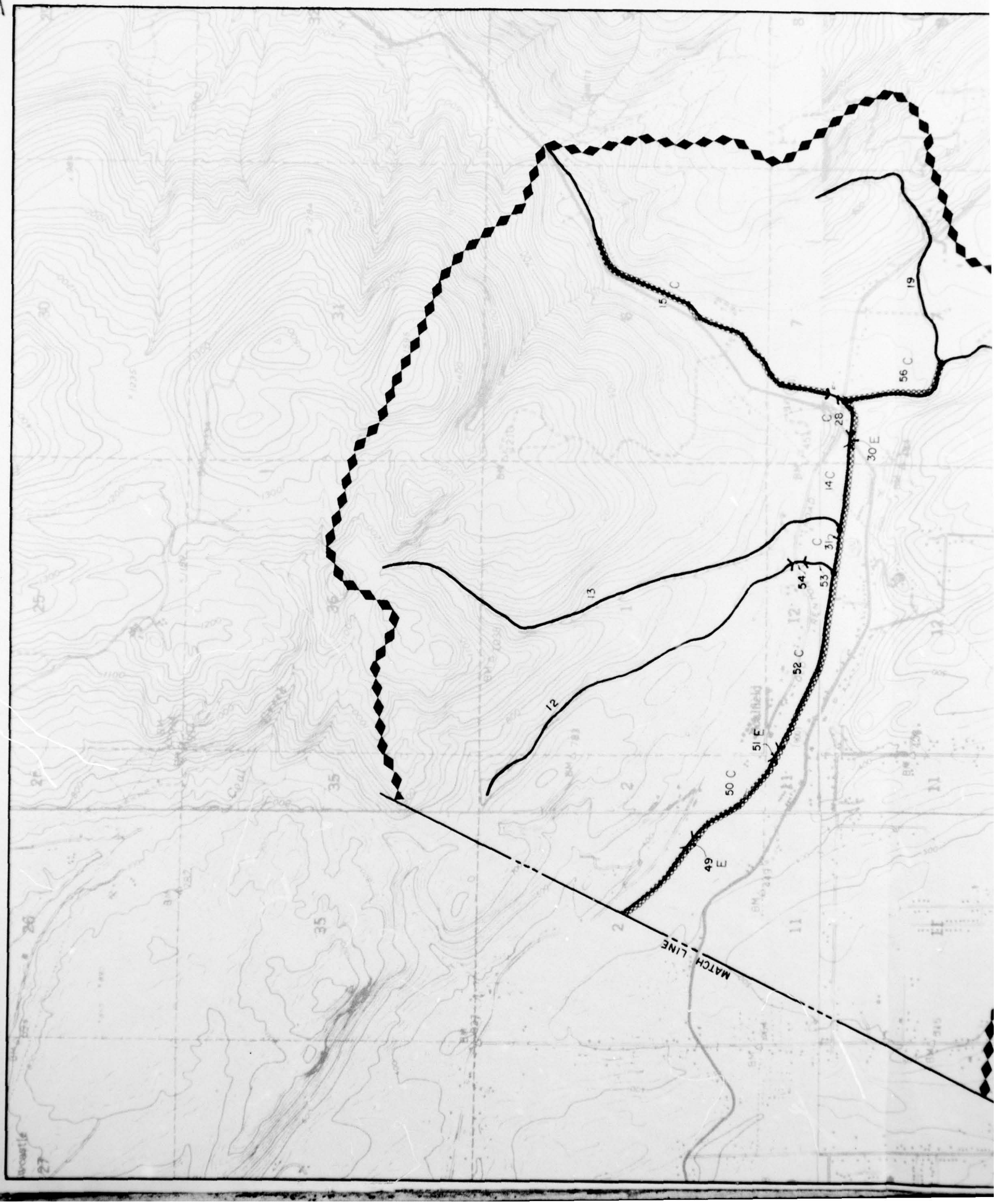
MAY CREEK DEMONSTRATION AREA

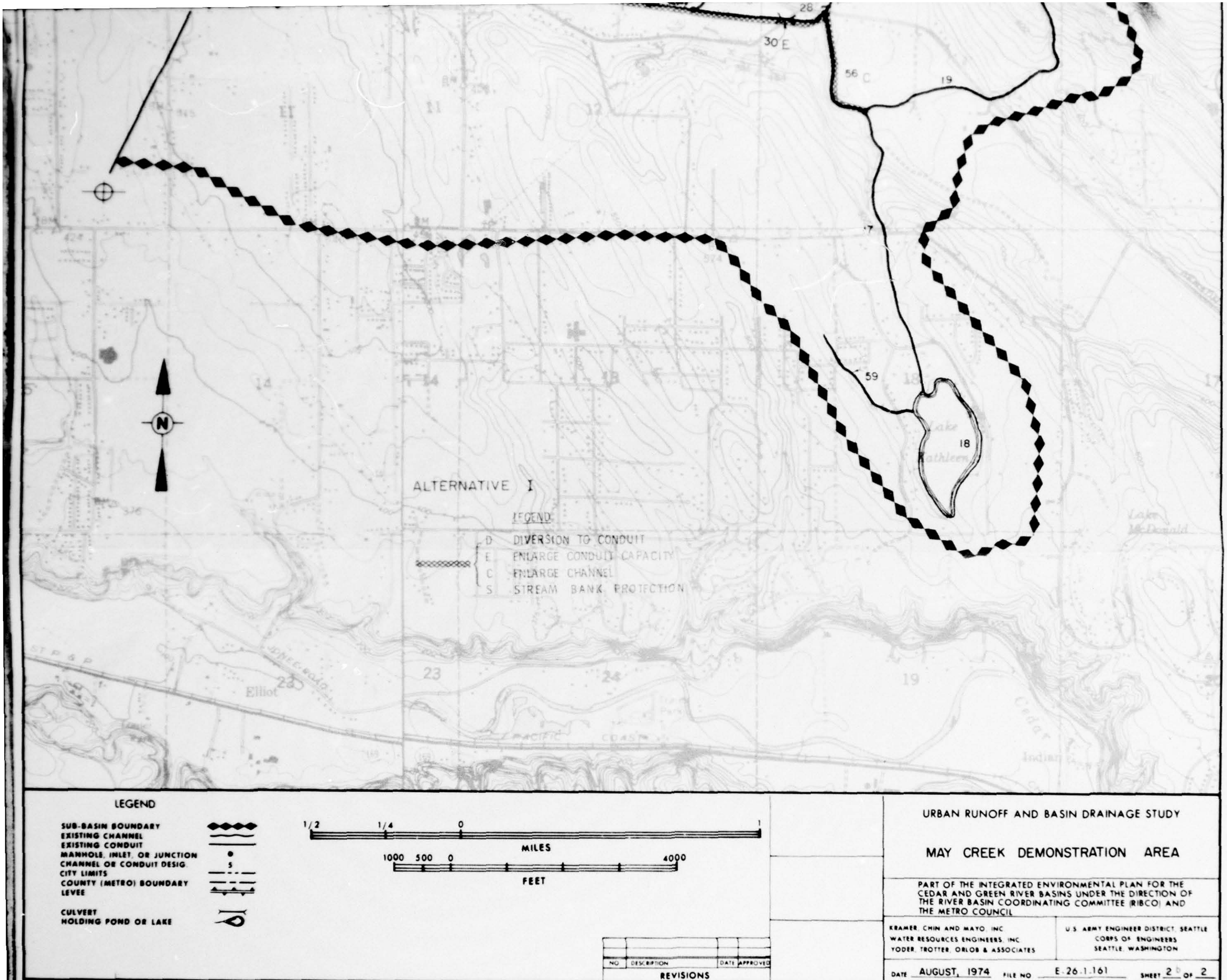
PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

KRAMER, CHIN AND MAYO, INC
WATER RESOURCES ENGINEERS, INC
YODER, TROTTER, ORLOB & ASSOCIATES

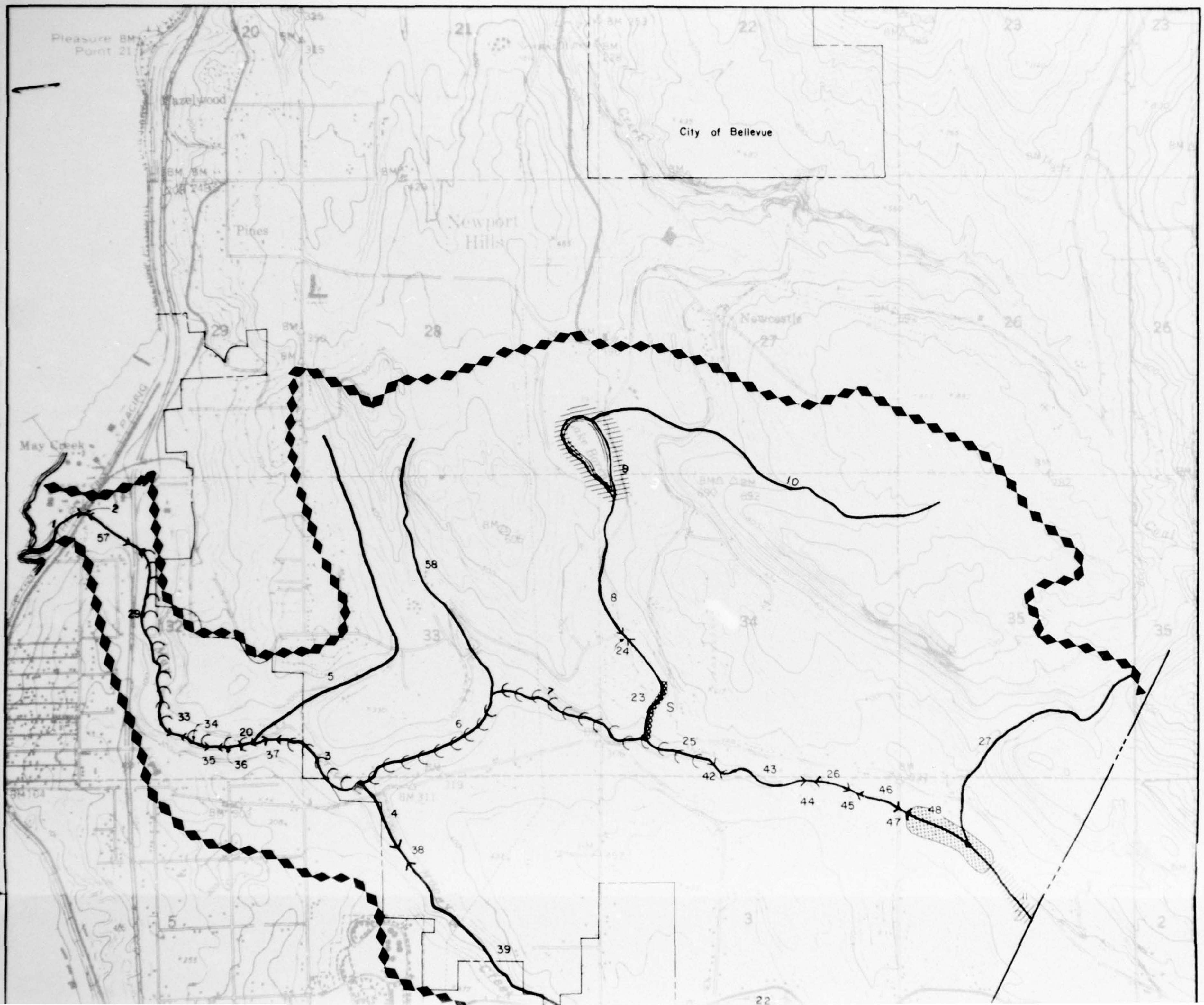
U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO E-26-1-161 SHEET 1b OF 2

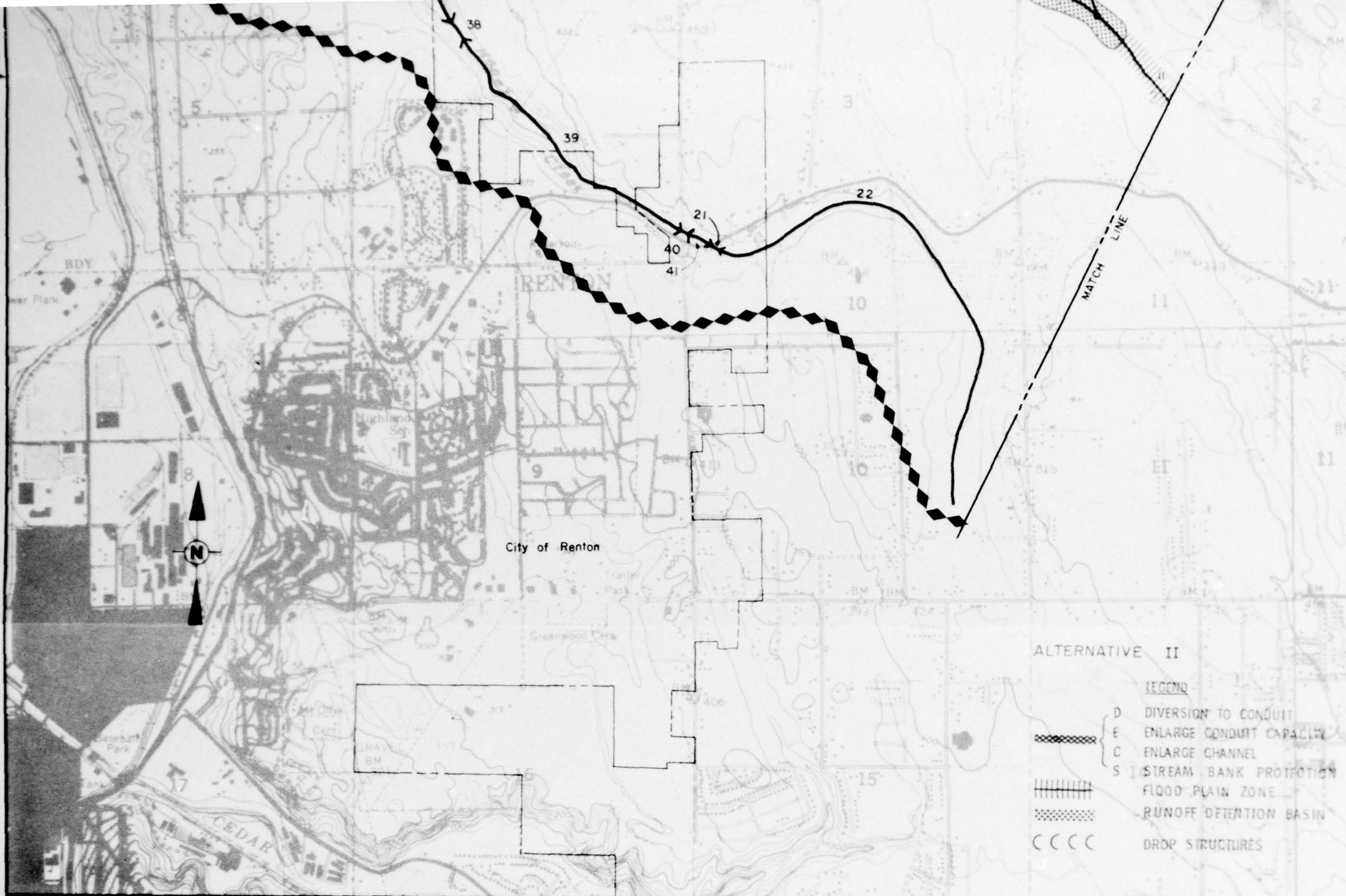

15 C
19
56 C
C
28
30 E
14 C
C
31
53
54
13
12
52 C
51 E
50 C
49
E
MATCH LINE



ALTERNATIVE I
LEGEND
D DIVERSION TO CONDUIT
E ENLARGE CONDUIT CAPACITY
C ENLARGE CHANNEL
S STREAM BANK PROTECTION
LEGEND
SUB-BASIN BOUNDARY
EXISTING CHANNEL
EXISTING CONDUIT
MANHOLE, INLET, OR JUNCTION
CHANNEL OR CONDUIT DESIG
CITY LIMITS
COUNTY (METRO) BOUNDARY
LEVEE
CULVERT
HOLDING POND OR LAKE
1/2 1/4 0 1
MILES
1000 500 0 4000
FEET
NO DESCRIPTION DATE APPROVED
REVISIONS
URBAN RUNOFF AND BASIN DRAINAGE STUDY
MAY CREEK DEMONSTRATION AREA
PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL
KRAMER, CHIN AND MAYO, INC
WATER RESOURCES ENGINEERS, INC
YODER, TROTTER, ORLOB & ASSOCIATES
U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON
DATE AUGUST, 1974 FILE NO E-26.1.161 SHEET 2b OF 2
Lake Kathleen
Lake McDonald
Elliot
Cedar



City of Bellevue
Newport Hills
Newcastle
Pines
Hazelwood
May Creek
Pleasure Point



LEGEND

SUB-BASIN BOUNDARY
EXISTING CHANNEL
EXISTING CONDUIT
MANHOLE, INLET, OR JUNCTION
CHANNEL OR CONDUIT DESIG.
CITY LIMITS
COUNTY (METRO) BOUNDARY
LEVEE

CULVERT
HOLDING POND OR LAKE

1/2 1/4 0 1
MILES
1000 500 0 4000
FEET

NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

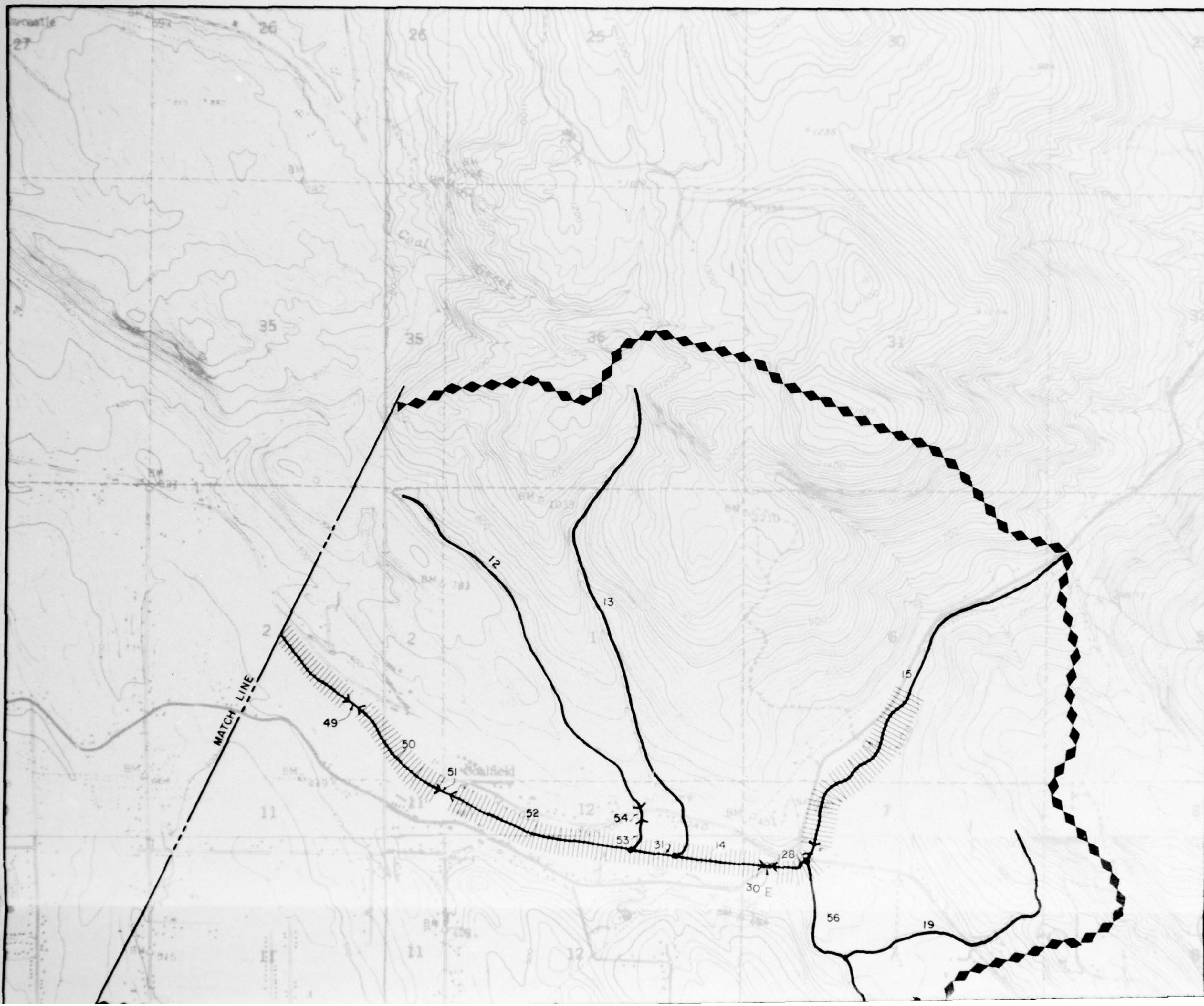
MAY CREEK DEMONSTRATION AREA

PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

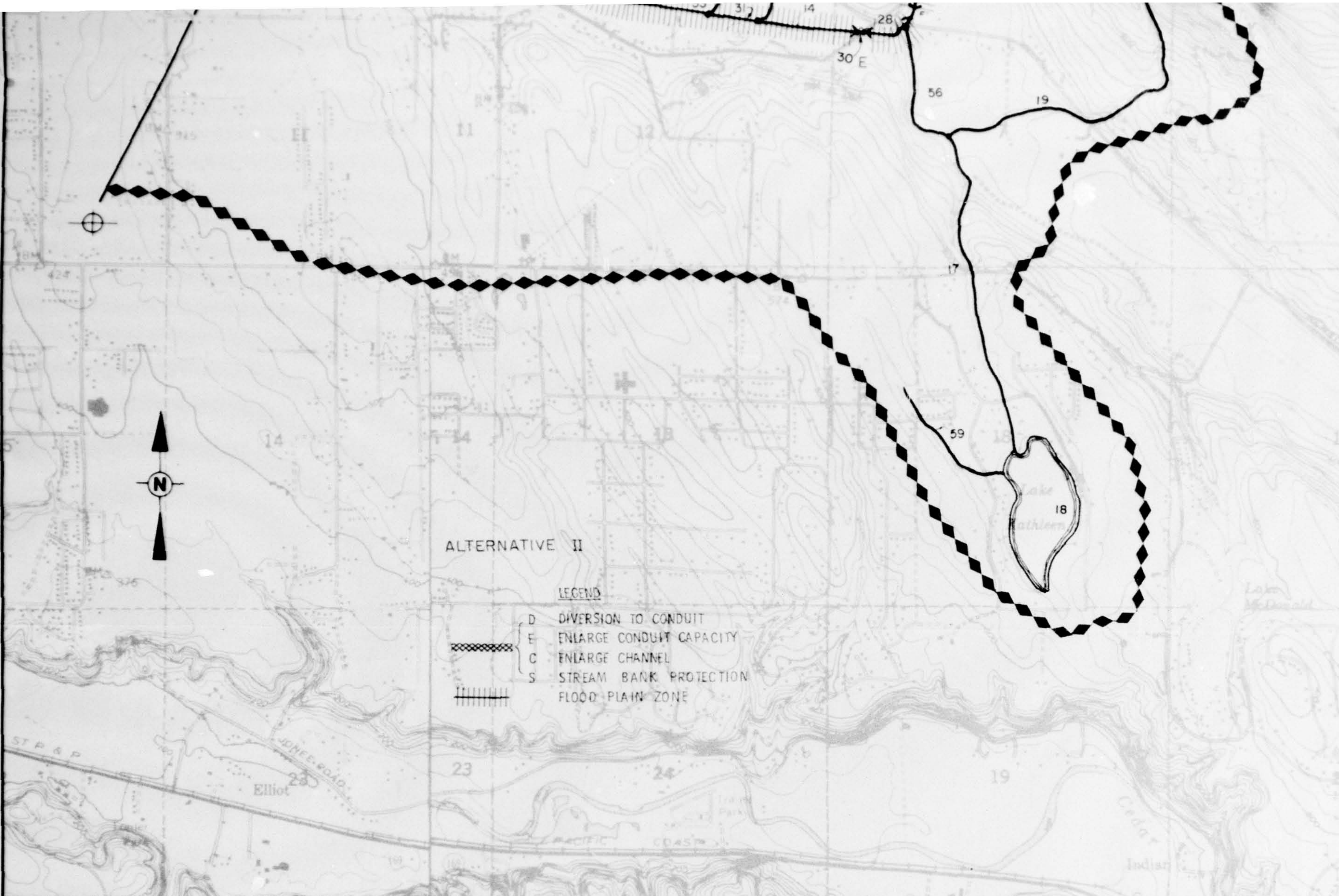
KRAMER, CHIN AND MAYO, INC
WATER RESOURCES ENGINEERS, INC
YODER, TROTTER, ORLOB & ASSOCIATES

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO E-26-1-161 SHEET 1c OF 2



MATCH LINE
Coal
Creek
Coalfield
2
12
13
14
15
19
28
30 E
31
49
50
51
52
53
54
56



LEGEND

SUB-BASIN BOUNDARY
EXISTING CHANNEL
EXISTING CONDUIT
MANHOLE, INLET, OR JUNCTION
CHANNEL OR CONDUIT DESIG. 5
CITY LIMITS
COUNTY (METRO) BOUNDARY
LEVEE

CULVERT
HOLDING POND OR LAKE

1/2 1/4 0 1
MILES

1000 500 0 4000
FEET

NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

MAY CREEK DEMONSTRATION AREA

PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

KRAMER, CHIN AND MAYO, INC
WATER RESOURCES ENGINEERS, INC
YODER, TROTTER, ORLOB & ASSOCIATES

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO E-26-1-161 SHEET 2c OF 2